POWER PLANT ENGINEERING

Established Over 29 Years

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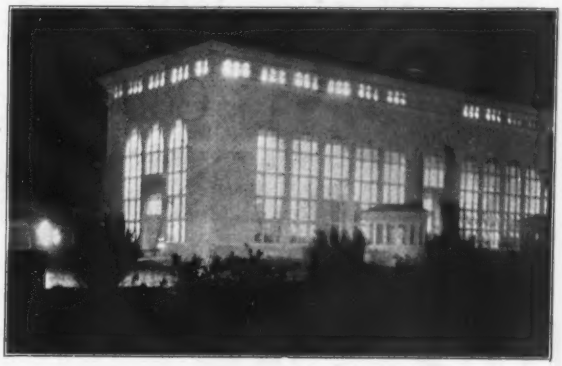
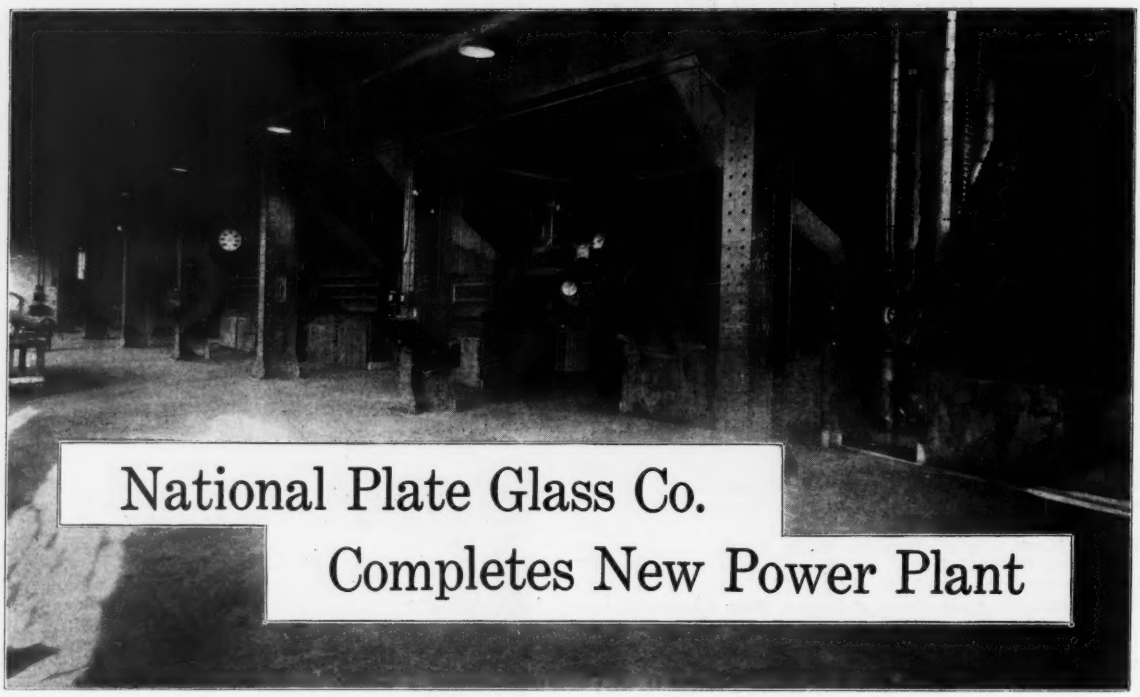


A Cameo on Black Velvet

GLOWING under the soft radiance of a thousand flood lights this alabaster-white structure stands silhouetted against the night sky like a cameo on black velvet. A thing of rare beauty, it brings to mind the classic Parthenon, the Taj Mahal or some fairy palace; certainly it gives no hint of anything commercial nor of anything so prosaic as a power plant. Yet, that's what it is, a power plant, not in the exact sense of the term, but its first cousin, a substation. It is the Vacca Substation of the Pacific Gas & Electric Co., near San Francisco and forms the southern terminus of the great 220,000 v. transmission line from the Pit River country.

Why can't more of our engineering and commercial structures possess some of the beauty of this substation? There is absolutely no reason why a factory, a power plant, or any business structure should be an eyesore to the community. The chances are, that if it is made beautiful in the first place, men will keep it so—they will take more pride in keeping it in good condition, and in that way there will be an actual return on the investment. But, regardless, of monetary considerations, we owe it to ourselves to live among beautiful surroundings and we should make every effort to satisfy that debt. Our power plants, to be sure, are first and above all, structures of utility; there is no question about that, but a little art injected into their design would in no way detract from their usefulness. The Pacific Gas and Electric Co. has done notable work along this line and the striking beauty of Vacca Substation is characteristic of many buildings which they have recently erected.



National Plate Glass Co. Completes New Power Plant

POWER PLANT OF 10,500-KW. GENERATOR CAPACITY IS PART OF NEW SEVEN MILLION DOLLAR FACTORY AT OTTAWA, ILL.

MAKING PLATE glass is a wonderfully interesting process. To see large piles of sand at one end of a glass factory transformed at the other end into the clear, transparent, slabs of stuff we call plate glass, to the uninitiated, must seem to require a touch of magic—an Aladdin's lamp, so to speak, capable of commanding the unlimited power of some genie. It does not seem logical that any ordinary process could bring about such a complete change in structure as that which exists between sand and glass. For, what is glass? At the Ottawa plant of the National Plate Glass Co. they told us it was composed of the following ingredients: Sand, calcium carbonate, sodium carbonate, sodium sulphate, sodium chloride, arsenic and powdered charcoal. Mix them in proper proportion, heat them sufficiently, roll it into slabs and when it cools the result is glass.

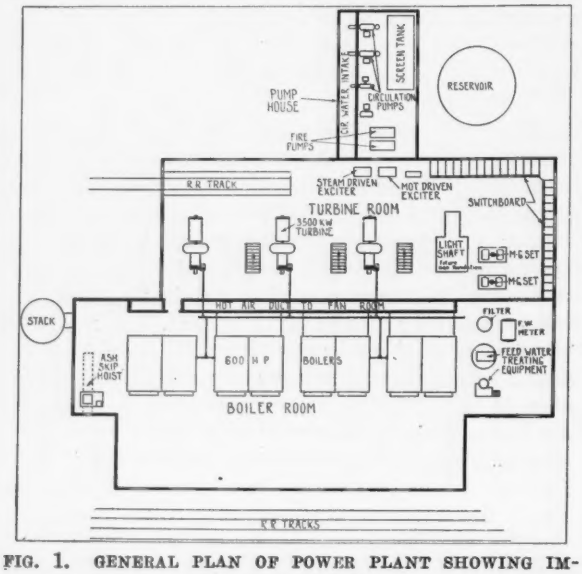


FIG. 1. GENERAL PLAN OF POWER PLANT SHOWING IMPORTANT EQUIPMENT

Simple, isn't it—nothing very mysterious and no necessity for the intervention of a genie. There *is* a genie, however, not, perhaps, the kind of a genie you visualize, from a knowledge of the Arabian Nights, but a genie, nevertheless. His name is "Power."

As in all other modern manufacturing processes, so in the manufacture of glass, power, in the form of electricity and heat is the indispensable commodity which transforms the raw material into the finished product. At the new Ottawa plant of the National Plate Glass Co., for instance, it requires a power plant of some 5000 boiler horsepower capacity to satisfy the power requirements.

This great glass factory has just been completed, having been placed in operation on June 17. It is built on a site covering 60 acres and is equipped with the most modern machinery for glass making.

Before going into a detailed description of the power plant, which of course is the purpose of this article, let us discuss briefly the making of glass so that the power requirements may be better understood.

The raw materials, high grade silica sand and the other ingredients listed above, are mixed in a dry state in a manner similar to that used with concrete and placed in fire clay pots. These pots are then placed in the equivalent of an open hearth furnace and the temperature gradually raised until the melting is complete. The pot is next removed from the furnace by a traveling crane and the molten glass dumped on a water-cooled cast-iron table where it is rolled into a sheet about ½ in. thick by an air-cooled cast-iron roller. After the plate has cooled sufficiently to be capable of being pushed by its cold edge it is

forced through a long series of annealing ovens by mechanical methods.

Up to this point the power used, aside from that used in heating, is mainly that used to mix the ingredients and conveying the product. All mixing machinery and conveyors are driven by electric motors.

The next step in the process consists of grinding and polishing. This is done on large circular tables similar to the table of a boring mill. The glass is secured to the table top by means of plaster of Paris, and grinding is accomplished with sand and water between cast iron blocks. These blocks are secured to two large disks or runners which are lowered to make contact with the top of the glass on the revolving table. The rotation of the table produces a torque on the two "runners" which revolve freely in their bearings and pick up a speed intermediate to the table.

After several grades of sand and emery have been applied in this manner and the glass is as smooth as it is possible to make it, it is ready for polishing. The table is then stopped, removed from the spider, transferred to another machine which is similar so far as the driving mechanism is concerned, but having in place of cast-iron blocks, pieces of felt saturated with iron oxide—"rouge". which is used as the polishing medium.

The grinding and polishing process is then repeated on the other side of the glass, after which the glass is removed from the table, washed with acid to remove the plaster, and, when dry, cut up into desired sizes and placed in stock.

As might be expected, the grinding and polishing process requires a considerable amount of power. At the Ottawa plant, there are eight grinders and eight polishers, each of the former being driven by a 500-hp. motor and the latter by 700-hp. motors, a total of 9600 hp. In addition to these large motors, however, there are a great many smaller motors, making a total of 336 motors in the plant.

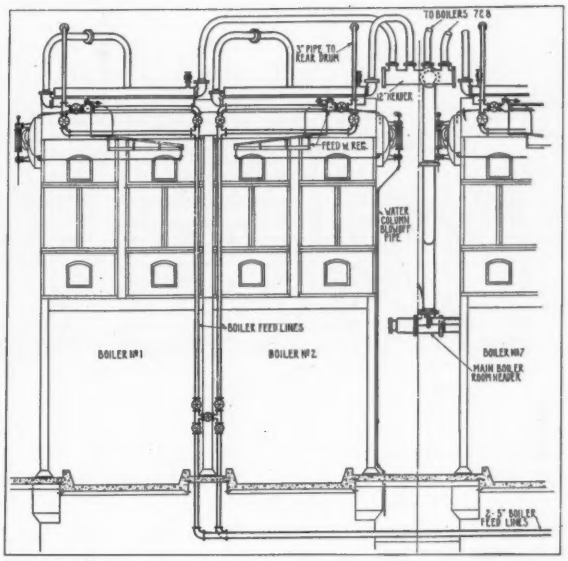


FIG. 2. FRONT ELEVATION OF A PORTION OF THE BOILERS SHOWING THE PIPING ARRANGEMENT

General Features of the Power Plant

The power plant which furnishes all steam, electricity and water for this factory is exceptionally well designed

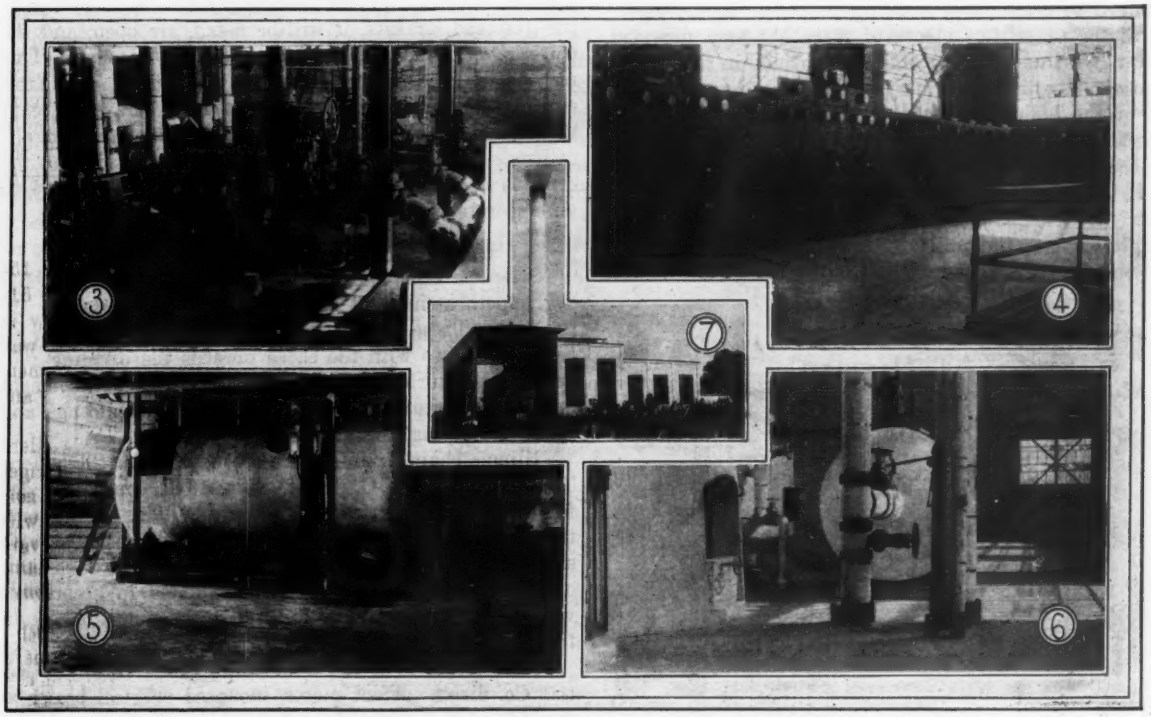


FIG. 3-7. A FEW OF THE MANY POINTS OF INTEREST AT THE OTTAWA PLANT

Fig. 3. Three hydraulic pumps furnish hydraulic pressure to the factory. Fig. 4. The switchboard composed of 35 panels is made up entirely of truck type units. Fig 5. Condensate and returns from the factory are collected in this receiver. Fig. 6. The filter and water meter in the treating room. Fig. 7. An exterior view of the plant showing the coal handling crane and the over head coal bins.

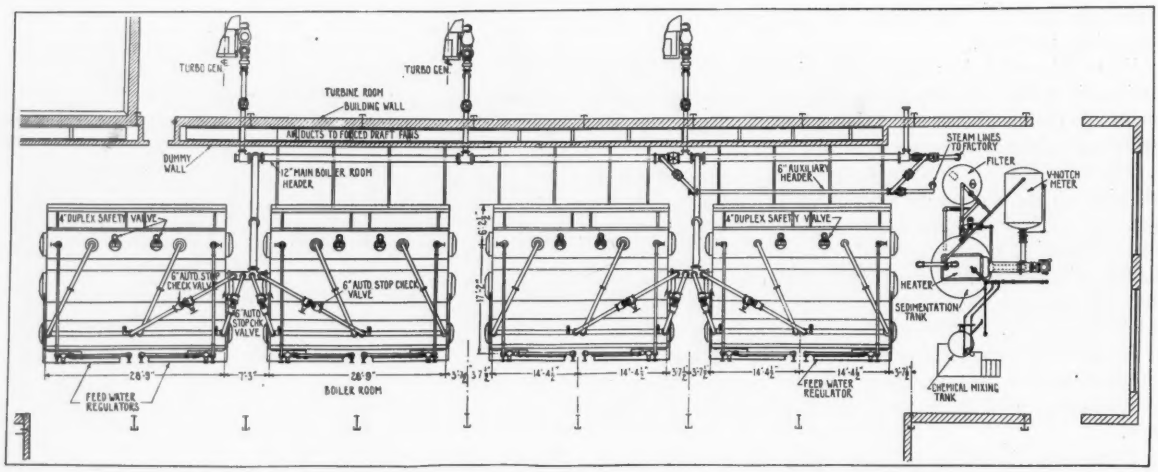


FIG. 8. PLAN OF THE BOILER ROOM SHOWING MAIN STEAM PIPING

from an engineering standpoint. It is located on the bank of the Illinois River some 200 ft. from the factory, so an ample supply of condensing water is available.

The general layout of the power plant is shown in Fig. 1. As will be noted, it consists of a turbine room, a boiler room and a pump house. The turbine room, which is 162 ft. long and 57 ft. wide, contains three 3500-kw. turbo-generators, furnishing current of 2300 v. Steam is generated by eight 600-hp. water-tube boilers.

The building is of steel frame construction with brick walls and concrete floors and foundations. Abundant natural illumination is secured during the daytime by large windows on all sides of the buildings, supplemented by monitor lights in the roof. The equipment has been arranged with a view of securing simplicity in the piping but at the same time plenty of space has been provided. A 20-t. Whiting traveling crane is provided in the turbine room for handling machinery. The stack, located at one end of the building, is of concrete, 241 ft. high, 14 ft. wide at the top and 18 ft. at the bottom. It was built by the Rust Engineering Co. of Pittsburgh.

In addition to supplying steam for process work and electricity, the plant also furnishes hydraulic power and compressed air; in fact, it satisfies all factory power requirements except that used in heating the glass furnaces.

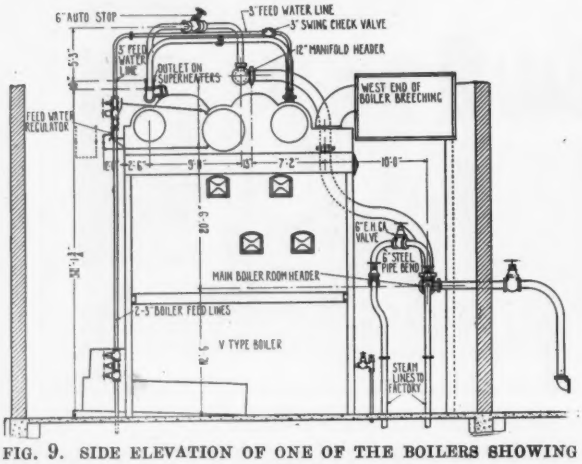


FIG. 9. SIDE ELEVATION OF ONE OF THE BOILERS SHOWING PIPING

Those are heated by gas, derived from two gas producer plants on the premises. Each of these plants has five mechanical gas producers capable of gasifying 150 t. of coal per day or a total of 300 t. for the two plants.

Traveling Crane Handles Coal

Coal is delivered to the plant direct by railroad over either the Chicago, Burlington and Quincy or the Chicago, Rock Island and Pacific Railroads. The method of handling the coal is simple and rapid. As may be seen from the accompanying photograph showing the exterior of the plant, a traveling crane is provided on the outside of the plant. This crane is equipped with a grab bucket by means of which the coal from railroad cars is transferred directly into the overhead bunkers feeding the stokers. The tops of the overhead bunkers, it will be noted, are open, and the traveling crane spans both the bunkers and the track. This method of handling coal, it must be obvious, eliminates entirely the necessity for track hoppers, traveling conveyors and bucket elevators with their attendant complications. Furthermore, the plant is so designed that the crane is also used to handle the ashes, thus dispensing with an elaborate ash handling system.

Eight 600-hp. Boilers Installed

Steam is generated at a pressure of 250 lb. with 150 deg. superheat in eight Heine, V-type boilers rated at 616 hp. each. These boilers are installed in a single row in batteries of two with the backs towards the dividing wall between the turbine and boiler room. This arrangement lends itself naturally to the scheme of the buildings and facilitates piping connections to the turbines.

Illinois chain grate stokers are used under all boilers. These are the type G., 10 ft. wide, 13 ft. long, arranged for forced draft operation. They are built to operate continuously, at 200 per cent of rating, and are fitted with six wind boxes which permit the air supply through various parts of the fuel bed to be regulated in accordance with the thickness of the bed and the combustion conditions at those parts.

Each stoker is driven by a 5-hp., 220-v. General Electric Co. direct current motor, mounted on steel beams at the side of the stoker about 7 ft. above the floor and connected to the stoker drive pulley by belt. These motors have a speed range of from 400 to 1600 r.p.m., control being effected through the use of General Electric drum con-

trollers mounted on the steel columns in front of the boiler.

Coal is fed to the stoker hoppers directly from the overhead coal bin, by means of chutes as shown in the general view of the boiler room.

All boilers are fitted with Copes feed water regulators, Reliance water columns and 8 units of Diamond soot blowers. The superheaters are those of the Superheater Co. An Ashton, 4-in. Duplex safety valve is mounted on each boiler.

Steam and air flow is measured and recorded by a Bailey boiler meter connected to each boiler. These meters are also equipped with a flue gas temperature recorder which has a bulb extending entirely across the path of the gases where they leave the boiler. A record of the flue gas temperature on the same chart with the steam flow and air flow gives a positive check upon the condition of the boiler heating surface and the baffles, and these daily records show whether or not the blowing of tubes and maintenance of baffles is receiving proper attention. These meters are mounted at the front of each boiler where the operators can at all times observe them.

Draft pressures in the furnace main draft duct and in each of the six wind boxes under the stokers is indicated by a Bailey Multipointer draft gage with eight pointers. These gages are mounted on the steel columns opposite the boiler meters so that the boiler operator has everything before him to obtain the desired capacity and best efficiency at all times.

Forced Draft Supply

Forced draft is supplied by four, size 7, Buffalo Forge Co., Turbo Conoidal fans driven by 230-v. G.E. d.c. motors, installed in a closed room in the boiler room basement. A long, concrete forced draft duct runs the entire length of the basement just beneath the stokers. This duct, however, is not continuous, but is bricked up at intervals so as to separate each pair of boilers. Each of the four chambers so formed is connected by a duct running at right angles to a fan in the fan room. In this way one fan normally serves two boilers, but in case of accident or trouble one fan could be made to serve more than two boilers by merely knocking out the brick dividing wall in the main duct. This wall could be removed in a few minutes, in fact, the brick could be allowed to remain in the duct until the defective fan was restored to service. This, of course, is purely an emergency provision, although the fans have sufficient reserve capacity to handle three boilers.

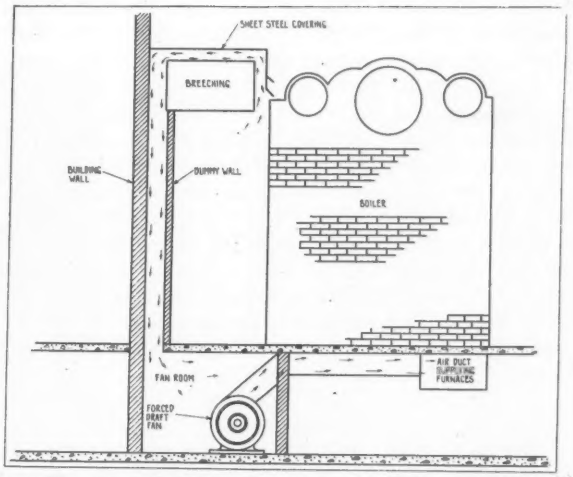


FIG. 10. AIR FOR FORCED DRAFT IS HEATED BY PASSING IT AROUND THE BREECHING IN THIS MANNER

An extremely interesting feature regarding the forced draft installation is the arrangement used to heat the air supplied to the forced draft fans. To explain this it is first necessary to refer to the upper part of the boiler room where the breeching is installed. The breeching which runs just back and above the boilers, the entire length of the boiler room, is constructed of steel, but is not covered with heat insulating material as is usually the case. Instead, there is installed, over the front and top of the breeching, a sheet iron covering, separated from the breeching by an air space of approximately 1 ft. The arrangement can be better understood from the diagram in Fig. 10. The breeching, it will be noted, is located about 2 ft. from the building wall and a dummy wall provided between the bottom of the breeching and the floor so that together with the sheet iron covering referred to, a continuous air space is provided around three sides of the breeching. This air space communicates directly with the forced draft fan room in the basement. It is apparent, therefore, that warm air from the upper part of the boiler room will be drawn around the breeching where it is heated to a still higher temperature by the flue gas into

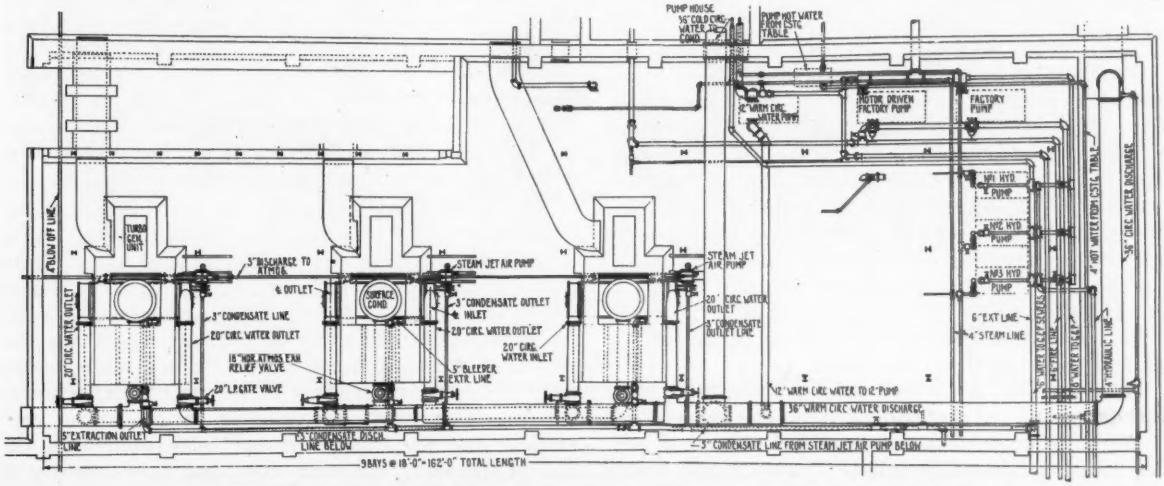

PUMP HOUSE
36" COLD CIRC. WATER TO COND.
PUMP HOT WATER FROM EST'G TABLE
12" WARM CIRC. WATER PUMP
MOTOR DRIVEN FACTORY PUMP
FACTORY PUMP
VH1 HYD. PUMP
VH2 HYD. PUMP
VH3 HYD. PUMP
TURBO GEN. UNIT
3" DISCHARGE TO ATMOS.
4" OUTLET
SURFACE COND.
STEAM JET AIR PUMP
3" CONDENSATE LINE
20" CIRC. WATER OUTLET
18" VAC. ATMOS. EXH. RELIEF VALVE
20" I-P GATE VALVE
3" CONDENSATE OUTLET & INLET
20" CIRC. WATER OUTLET
20" CIRC. WATER INLET
5" BLEEDER EXTR. LINE
20" CIRC. WATER OUTLET
3" CONDENSATE OUTLET LINE
6" EXT. LINE
4" STEAM LINE
12" WARM CIRC. WATER TO 12" PUMP
36" WARM CIRC. WATER DISCHARGE
36" CIRC. WATER DISCHARGE
4" HOT WATER FROM EST'G TABLE
4" HYDRAULIC LINE
5" EXTRACTION OUTLET LINE
5" CONDENSATE DISCH. LINE BELOW
5" CONDENSATE LINE FROM STEAM JET AIR PUMP BELOW
9 BAYS @ 18'-0" = 162'-0" TOTAL LENGTH

FIG. 11. PIPING ARRANGEMENT IN THE BASEMENT OF THE TURBINE ROOM

the fan room below. This not only keeps the boiler room comparatively cool, but results in an increase in the overall efficiency due to the heat reclaimed from the flue gases.

While the plant has not yet been operated at a capacity sufficient to show the economic value of this arrangement, the operators are well satisfied with it. The boiler room is maintained at a comfortable temperature and the temperature in the fan room seems to indicate a considerable gain in heat, so much in fact that it became necessary to build a ventilating housing on the electric motors driving the forced draft fans. This is nothing more than a galvanized sheet iron housing arranged at one end of the motor with a duct connecting to the outside of the fan room so that the heat generated in the motor itself may be carried away as quickly as it is produced.

Ash Handling

The method of handling the ash is simple. The ash pits which are equipped with Beaumont Mfg. Co. balanced

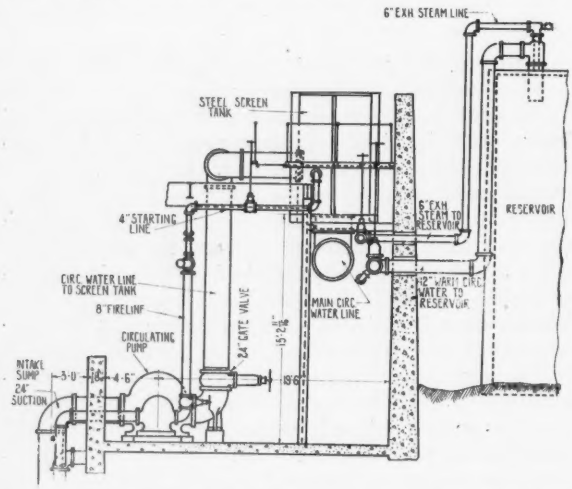


FIG. 12. CIRCULATING WATER PIPING AND SCREEN TANK IN THE PUMP ROOM

ash gates, empty into an industrial type car running on tracks below. At one end of the room the ashes are dumped into a hopper and then by means of a Beaumont skip hoist are carried to an overhead ash bin for further removal from the plant.

Feed Water Supply and Method of Treating

Make-up feed water is river water, treated by a hot process lime soda softener made by the Cochrane Corporation. This latter consists of a heater, a sedimentation chamber, a chemical mixing tank, with chemical proportioner and a sand filter. The heater which is mounted on top of the sedimentation tank, is divided into two compartments, one for raw make-up water and the other for condensate returned from the system.

Water testing apparatus is provided so that the operators may make daily tests of the raw water, the results of the tests being applied in the proportioning of the chemicals introduced into the water.

There are four boiler feed pumps, two of which are steam driven and two electrically driven. The steam pumps are Worthington, duplex, outside packed plunger pumps, fitted with Copes pump governors. The electrically driven pumps are Cameron, 4-stage centrifugal units, rated at 500 g.p.m., under a head of 638 ft. when operating at 1750 r.p.m. They are direct connected to 150-hp., 2200-v. General Electric Co. induction motors. A pressure of about 280 lb. is carried on the feed water lines, this being some 30 lb. over that of the normal boiler steam pressure.

All returns from various parts of the factory and all condensate from the main condensers is returned to a large receiver in the basement. This tank is divided into two parts, one half for condensate and the other for returns from the system. From this tank, which is shown in Fig. 5, the water is pumped into the feed water heater. The amount of feed water supplied to the boilers is measured by a V-notch meter.

Exhaust steam for heating the feed water is derived from the steam driven auxiliaries such as the boiler feed pumps, the fire pumps and the air compressors.

The Turbine Room

As stated at the beginning of this article, all electricity is generated at 2300 v., 60 cycles, by three General Electric Curtis turbo-generators. These are located along one side of the room with their steam ends toward the boiler room. Each unit consists of a 14-stage, 3500-kw. condensing type turbine direct connected to a 4375-kv.a. 2300-v. 3-phase, 60-cycle generator.

Exciting current is supplied by two separate exciters, one a steam driven unit used only when starting up the plant and the other, an electrically driven set. The latter consists of an 87.5-kw., 125-v. d.c. generator driven by a 130-kv.a., 2300-v. G. E. synchronous motor. The steam driven exciter is a 50-kw., 125-v. machine.

Each turbine exhausts into a Wheeler Condenser & Engineering Co. 2-pass surface condenser with 7000 sq. ft. of cooling surface. These are installed in the basement directly underneath the turbine. An interesting feature of the condenser installation is that the circulating water is supplied through a common supply line. The circulating pumps themselves are located in the pump house some distance away. There are three circulating pumps, two large pumps of 24-in. diameter, made by the Wheeler Condenser & Engineering Co. driven by 250-hp. G. E. induction motors and one small pump made by the American Well Works, driven by a 20-hp. G. E. motor.

Direct current for use in the power plant and factory is furnished by two motor generator sets located at one end of the turbine room. These units shown in Fig. 18, are of General Electric Co. make and consist of 250-v., 700-amp. direct current generators direct connected to 240-kv.a., 2300-v. synchronous motors. The synchronous motors used on these sets and also on the electrically operated exciter, aid in maintaining a good power factor on the system, which because of the large number of induction motors used, tends to assume a low value.

The switchboard controlling the generation and distribution of all electricity is shown in Figs. 4 and 15. It is made up entirely of the truck type panel units. These consist of a permanent and stationary housing and removable trucks. The stationary housing encloses the bus bars, the terminals for incoming or outgoing cables and the stationary disconnecting devices. The removable trucks carry the oil circuit breakers, current and potential transformers, the movable disconnecting devices, copper connections and the instrument and relay equipment. In case of trouble on one unit or in case it is necessary to inspect the switching equipment, the trucks are merely

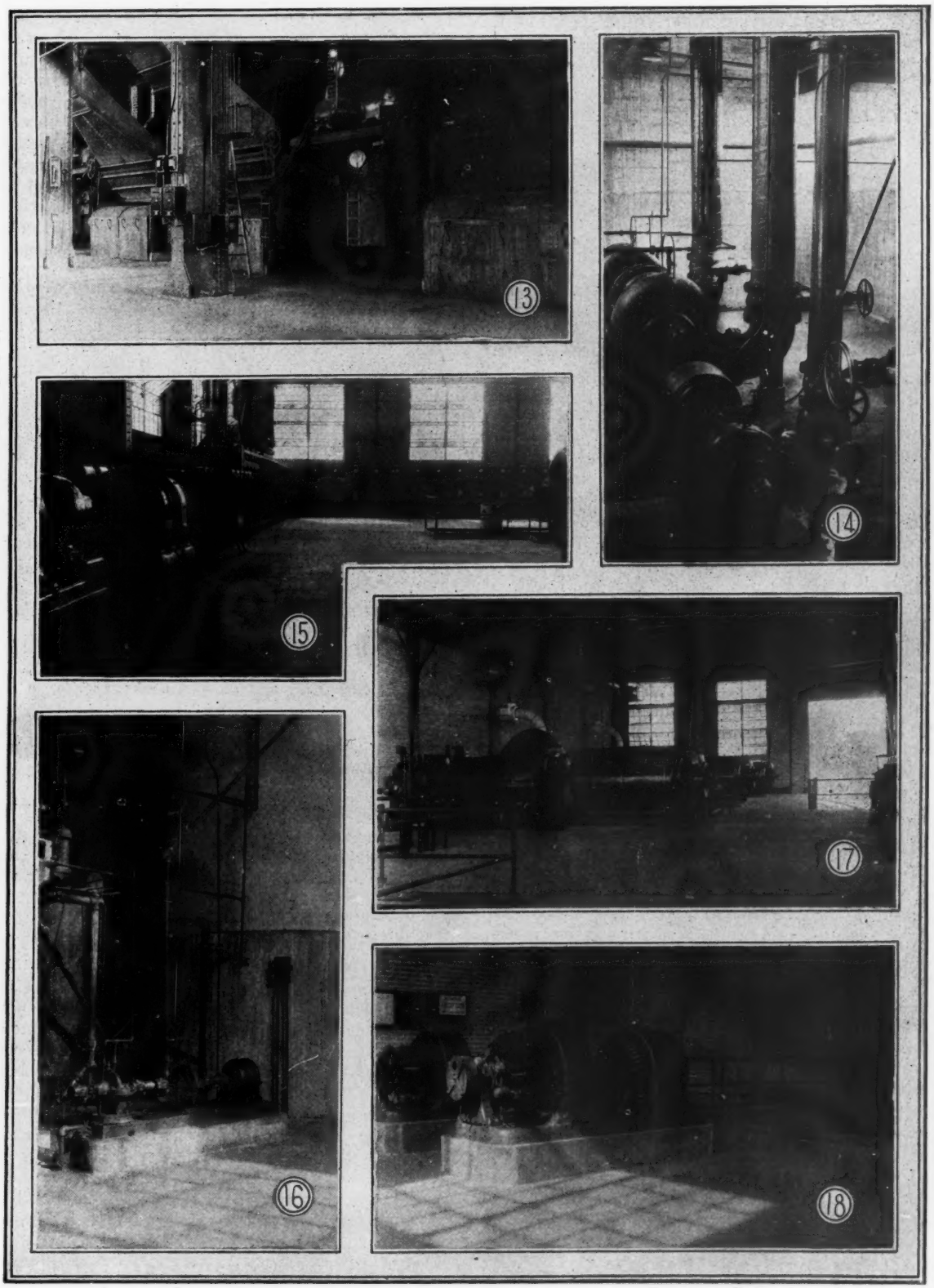


FIG. 13-18. A ROOMY ATMOSPHERE PREVAILS THROUGHOUT THE PLANT

Fig. 13. Each stoker is driven by a D. C. motor at the side of the furnace. Fig. 14. The main circulating pumps. Fig. 15. Another view of the switchboard. Fig. 16. A portion of the water treating apparatus. Fig. 17. General view in the turbine room. Fig. 18. Motor generators furnish direct current.

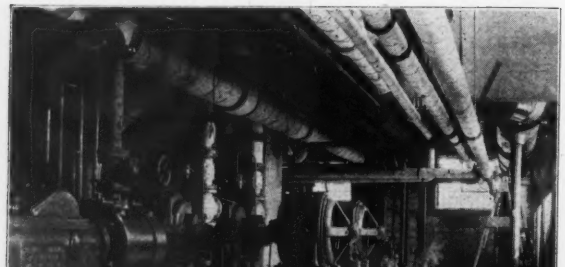


FIG. 19. LOOKING ALONG ONE SIDE OF THE BASEMENT. MOTOR DRIVEN BOILER FEED PUMPS IN THE FOREGROUND

removed from the permanent housing and run out onto the floor. If necessary the faulty truck can be replaced immediately with a spare unit until repairs are completed.

The board is constructed of steel throughout. All live parts are entirely enclosed and interlocks are provided so that a truck cannot be removed until the oil circuit breaker has been opened.

In Fig. 4, the three generator panels are shown approximately in the center of the picture. The panels along the end of the turbine room are the feeder panels controlling the 500 and 700-hp. induction motors driving the polishers and the grinders in the factory. Each motor has its individual panel. In all, the switchboard consists of thirty-five separate panels.

Pumping Equipment

In addition to the pumps required in the operation of the power plant proper, there are installed in the basement a number of other pumps for factory service. For service to the hydraulic lifts in the factory, for instance, there are provided three Worthington hydraulic pumps, of the outside packed plunger type, built for a working pressure of 1000 lb. per sq. in.

The general factory service water supply is taken care of by two motor-driven two-stage centrifugal pumps made by the American Well Works. Another American pump provides warm circulating water from the condensers for

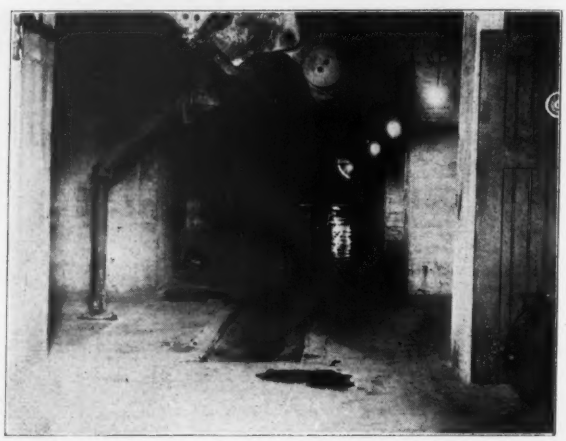


FIG. 20. ASH IS REMOVED BY AN INDUSTRIAL CAR RUNNING BELOW THE ASH PITS

warming the water in the reservoir outside the pump house and also for factory use.

Circulating water pumps for the condensers and the fire pumps are located in the pump house, a rough plan of which is shown on the general building arrangement in Fig. 1. This pump house contains the intake sump from which the various pumps take suction and the screen tank. The circulating water passes through a coarse grating before entering the intake sump, and while this grating keeps back large size refuse, a considerable amount of fine material comes through. To remove this fine material a horizontal screen tank is provided at the upper part of the pump house as shown in Fig. 12. This is nothing more

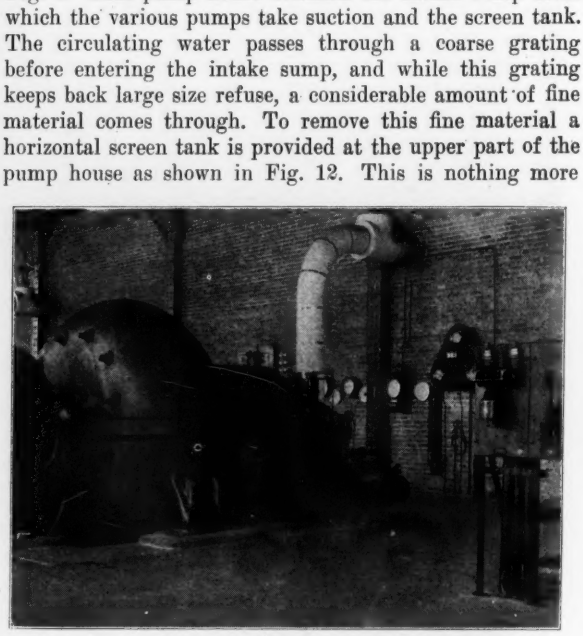


FIG. 21. ONE OF THE THREE TURBO GENERATOR UNITS

than a large rectangular tank with a screen laid in it in a horizontal position. The circulating pumps discharge the water on top of the screen. After passing through the screen the water passes into the main circulating line to the condensers. The condenser discharge line discharges into the river a short distance below the intake sump.

The fire pumps referred to are Worthington steam driven pumps, 20 by 12 by 16 in. and furnish the bulk of the exhaust steam used in heating the feed water. A small motor driven fire pump is provided for emergency purposes.

Miscellaneous Details

In addition to the steam supplied to the turbines and the power plant auxiliaries there is a considerable demand for high pressure steam in the factory. This steam is supplied through two 6-in. lines, both of which are equipped with a Bailey steam flow meter. A feature of interest regarding the high pressure steam piping to the main turbines and the factory is the 6-in. auxiliary header shown on Fig. 8. This is provided so that in case of accident to part of the main header, steam may be bypassed through the auxiliary header and the defective portion isolated. All pipe work was done by the Pittsburgh Piping and Equipment Co. Crane Co. valves were used throughout.

Compressed air is supplied at a pressure of 100 lb. by 2 steam driven air compressors.

Conclusion

This plant was designed entirely by the engineering staff of the company under the direction of J. M. Berg, general superintendent. All construction was done by outside firms under contract. In concluding this description we acknowledge our indebtedness to the officers of the company for their courtesy in co-operation with us in supplying the data used in the preparation of this article.

Low Temperature Carbonization in America

FUTURE LIES IN EXTRACTION AND SEPARATE SALE OF BY-PRODUCTS AND COMBUSTION OF COKE IN PULVERIZED FORM. BY H. W. BROOKS*

SO MUCH has been written and said on the subject of low temperature carbonization here in America during the past few years that it is worth while to pause and take stock of the situation in its reference to our particular needs. Europe, confronted by different and more pressing problems of mining, military, agricultural and combustion engineering and economics, has been forced to take the lead on research in conservation methods conducive to greater domestic production of oils, gases, ammonium sulphate and smokeless fuels. We, in properly interpreting their results for our maximum benefit, must ask ourselves the following questions:

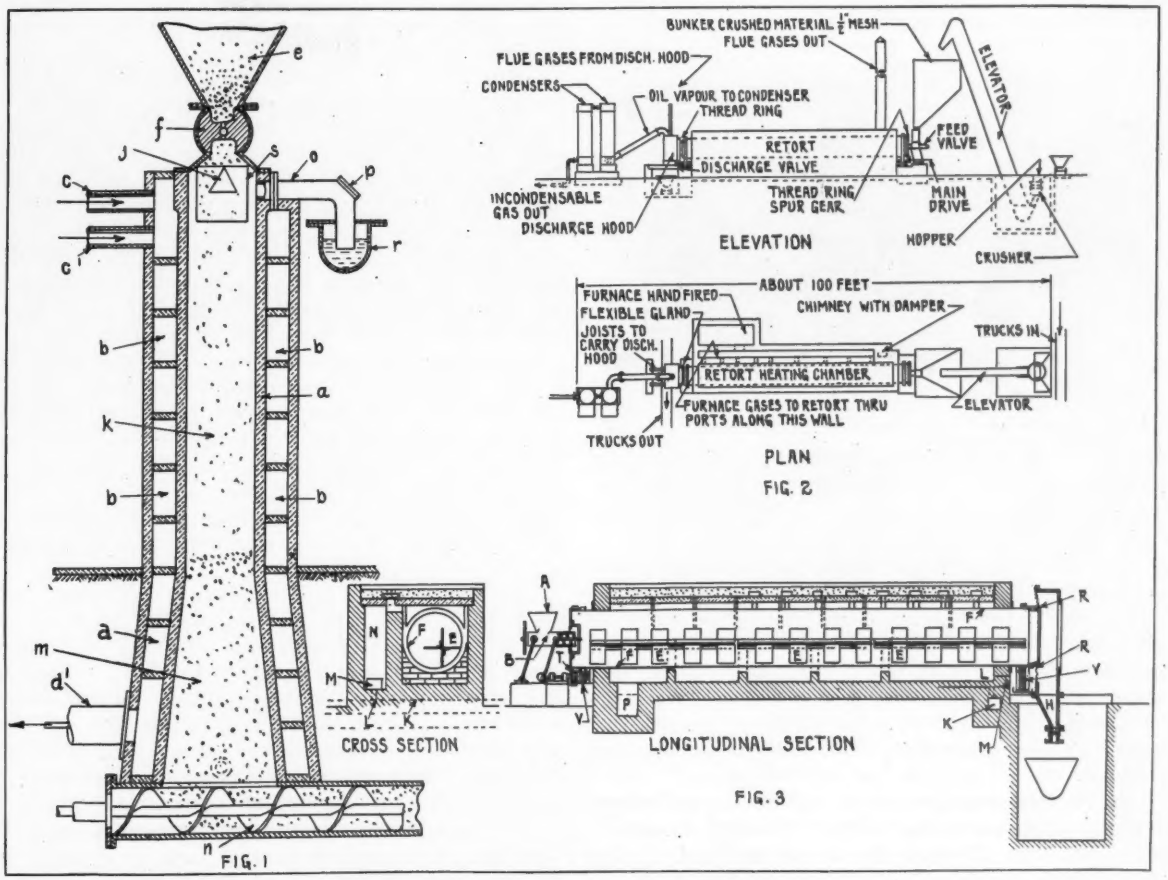
1. Wherein are our conditions the same and wherein different from those abroad?

2. Why must we seek a new method (low temperature carbonization) when the old well established and well understood high temperature methods are available?

3. If low temperature carbonization more satisfactorily solves our conservation problems, what process is to be preferred for our conditions, and why?

4. What are the disadvantages of the new method and how may they be overcome?

5. Is the preferred process as recommended practicable financially as well as technically under American conditions?



LOW TEMPERATURE CARBONIZING RETORTS

Fig. 1. Vertical shaft retort for carbonizing pulverized coal in suspension. Fig. 2. General layout of British "Fusion" Rotary Retort and auxiliary plant. Fig. 3. Longitudinal and cross-sectional view of the "Fusion" Rotary Retort. A. Raw material hopper. B. Air-tight automatic feed valve. E. Breaker or pulverizer. F. Rotating tube. G. Ports with dampers for conveying the products of combustion to the heating chamber round the rotating tube F. H. Hopper with air-tight automatic valve for discharge of spent material. K. Gas feed conduit. L. Gas inlet to combustion chamber. M. Air inlet to combustion chamber. N. Combustion chamber. P. Flue to chimney. R. Gland for making joint between rotating tube and end chamber. T. Gear for rotating tube. V. Rollers upon which the tube rotates.

To supply sensible, present day answers to these questions in view of our situation here is the object of this discussion.

AMERICAN AND EUROPEAN CONDITIONS COMPARED

The majority of commercial scale installations of low temperature distillation have been made in Europe. There the better grades of coal such as are now being mined in the United States have been worked out years ago. Most of the British, French and German mines are from two to three times the average depth of the American bituminous

*Consulting Engineer, Fuller-Lehigh Co.

mines, resulting in much greater overhead pressures on the coal seams, which in turn produce much higher percentages of fine sizes in mining. For these two reasons the majority of European bituminous coals are washed and sized. Of the total American bituminous production, on the other hand, less than 5 per cent. at present is beneficiated. The problem, therefore, of disposition of fine sizes of bituminous in Europe is even more pressing than our well known American problem of anthracite fines. Furthermore, the central heating system, in which fine coal can be burned if necessary for domestic service, has been relatively little adopted—particularly in England, the old open fire grate still being principally relied upon. Europe, therefore, is of necessity forced either to briquette or waste a large portion of her bituminous fines.

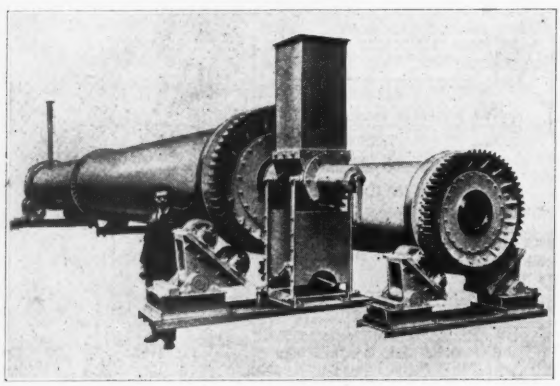


FIG. 4. ASSEMBLY OF "FUSION" RETORTS, CAPACITY EACH 30 T. PER DAY. ONE TO THE RIGHT HAS FEED VALVE REMOVED

This is not the case in America and will probably not be for the present generation. Briquetting costs money and as long as American coal operators can dispose of their slack for steam purposes at reasonably profitable prices, it will not pay further to classify and briquette it. The higher per capita power consumption and the greater development of the electrical public utility in America both contribute to greater stability of the slack market here than there.

As for European domestic oil supply, it is well known that the oil reserves during the World War were on occasion dangerously low. European Navies and merchant shipping were and are now almost entirely dependent upon overseas supplies of fuel oil. In 1920, for example, of the total world oil production of about 97,000,000 t., the United States produced 64.8 per cent. and Mexico 23.3 per cent. In the Jan., 1925, issue of Mechanical Engineering, in an article called "Engineers and the American Petroleum Situation," Dr. Julian D. Sears of the U. S. Geological Survey estimated that if our consumption of oil could continue without increase at the 1923 rate of 700,000,000 bbl. we would entirely exhaust all known domestic reserves recoverable by present methods within 11 yr.

Whether or not the geologist's estimate of our total reserve proves too low, "the vital fact remains—our supply is not inexhaustible and when once extracted it is gone forever." What will actually happen, of course, is that domestic consumption will continue to increase as in the past and "the actual result of approaching exhaustion will be declining production and increasing dependence on other sources of petroleum" (with ever increasing transportation or manufacturing costs necessarily added). The present generation has seen this happen in the natural gas fields. Have we any reason to expect that Nature will function differently with respect to oil? Certainly, therefore, advancing oil prices are inevitable.

Inefficiency in Extraction Must Be Improved

Present day inefficiencies in the extraction and use of oil can, must and will be eradicated—always, however, at the expense of increased equipment costs. The much discussed alternative sources of domestic oil production, oil sand and oil shale, will require enormous investments to develop (of the order of the present total investment in the coal mining industry). Unlike petroleum, these oils cannot be labor cheap. They thus offer little hope in stemming the tide of advancing prices.

Synthetic oils like "Synthol" and "Methanol" and those produced by Franz Fischer and Bergius in Germany by liquefaction or so called "Hydrogenation" of coal (at pressures of 150 atmospheres or more) lie even further from the range of present day price competition with fuel oils. This is still more true of processes proposed for industrial alcohol distillation from vegetable wastes. Due to the relatively small oil yield of high temperature distillation processes, the supplying of an appreciable percentage of our national oil resources therefrom would result in an unmarketable production of high temperature coke.

Low temperature carbonization, on the other hand, can supply not only our oil requirements but simultaneously our needs for cheap electric power, an efficient smokeless domestic fuel, an enricher for city gas supply, and a source of supply for ammonium compounds. All these may be produced from cheap bituminous fines which are practically a by-product of an existing industry at relatively small additional investment at power plants already having enormous fuel requirements.

As the demand for coal for power is greater and vastly more concentrated than that for heating, hence offering greater possibility for large scale oil production at minimum investment cost through pretreatment, the author has long felt that the immediate future for low temperature carbonization in America lay in extraction and separate sale of the valuable by-products and subsequent combustion of the semi-coke (low temperature coke) in pulverized fuel furnaces at large central power plants.

It is felt that the production at present of briquetted fuel here is of lesser importance both economically and from a conservation standpoint, that there is a lesser margin of profit to be expected from it and a less staple and dependable market for it than for electricity. In high temperature coke making for heating service the margin of profit has been found to be highly variable and dependent on many complex conditions generally beyond the operator's control. The domestic demand for coke is highly seasonable. Base load power plants located at or near mine mouths, practically guaranteed a reasonable margin of profit (as long as they are intelligently managed) through competent public regulation of rates, provide a dependable market for coke in which investment risks are reduced to a minimum, and ready capital easily available.

It is recognized that the conclusion that electricity rather than smokeless fuel should be the ultimate product of low temperature carbonization for the present is at variance with the opinion held by many authorities. So far, however, it certainly has not been commercially demonstrated even in Europe and much less in America that

the additional selling price obtainable for briquetted coke will pay for the additional process and briquetting costs incident to its manufacture. Certainly the public wants a smokeless domestic fuel. The problem of selling it to the public at a profit, however, still remains substantially unsolved.

Low Versus High Temperature Carbonization

Dealing specifically with the second question of this discussion low temperature processes are likely to be more economical, hence more profitable, than high temperature processes for pretreatment of bituminous coal for the following reasons:

1. The oils recovered will be in volume two or three times larger and probably eventually will prove of distinctly greater value per gallon than the high temperature tars, due to inherent chemical and physical differences which will be discussed later.

2. This high oil yield would not glut the market with unmarketable coke to produce a reasonable percentage of our domestic oil requirements as would probably be the case with the low oil yield, high temperature processes.

3. For power plants, low temperature coke is better adapted to more efficient combustion in pulverized form.

4. Low temperature coke fulfills the requirements for a smokeless and easily ignitible domestic fuel more desirably than high temperature coke, when prices justify its sale for such purposes.

5. Low temperature gases (from externally heated retorts) are higher, hence find a readier (and doubtless eventually a higher priced) market.

6. Initial investment costs, hence fixed charges, are lower, as are also labor and maintenance costs.

7. The sizes of pipes, tanks, etc., required in handling the volatilized products (from externally heated retorts) will be smaller.

8. Operating at a lower temperature, the former, with properly designed heating surface, will consume less fuel about the retorts in order to maintain the proper carbonizing temperature.

9. Less heat will be lost in the condensing system because of the lower temperature of the various products evolved.

Processes for Low Temperature Carbonization Preferred

Later in this discussion it will be demonstrated that with low temperature carbonization the present day value of the primary by-products alone when recovered in connection with electric central station operation, will in many cases pay for the entire costs, including fuel, overhead and fixed charges of pretreatment. In such cases, therefore, the value of the semi-coke (70 to 75% of the original coal) used for power generation is clear gain. In other words, extraction and separate sale of the primary by-products under these conditions permits the use of an efficient fuel for power which costs nothing. In view of the foregoing, it is felt that the low temperature process to be preferred here should be designed primarily with electric central station operation in view. It should hence be a continuous process of high throughput delivering its low temperature coke in as finely divided a state as possible for subsequent combustion in pulverized form. Producer gas or pulverized fuel should be used in firing the retorts (which should be externally heated) in order to release for sale as an enricher the entire production of high grade gas.

Two processes are available for accomplishing these objectives, the first employing the vertical shaft retort in which pulverized coal is carbonized in suspension, while the second utilizes a horizontal or inclined cylinder retort, in which lump coal is agitated in contact with heated metallic retort walls. The former type, one design of which is illustrated in Fig. 1, is still in the experimental stage both here and in Europe though it offers promising results. Many of the same factors contributing to the present success of combustion of coal in pulverized form would appear to contribute equally to the success of its carbonization in the finely divided state. In this type some form of vertical shaft retort is employed in which there is a large free space k. The combustible gas or pulverized fuel used in heating the retort is burned in annular combustion chambers or spaces surrounding the retort in such manner as to provide counterflow, parallel flow, or any combination thereof, of the heat transfer through the retort walls to

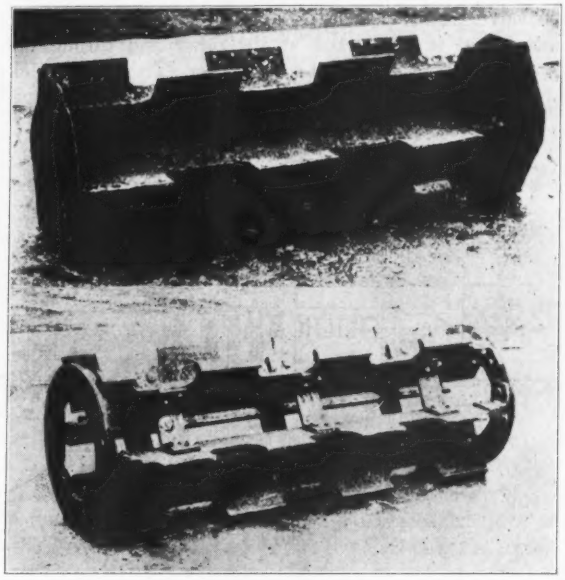


FIG. 5. TWO TYPES OF COAL BREAKERS TO PREVENT STICKING ON RETORT WALLS

give maximum yields and operating economies with a given coal. The coal is fed through the hoppers in a state of fine sub-division falling through the free space k where it is subjected to the radiant heat and cooling in the lower part where it collects and is removed by the screw n.

More elaborate retorts on this principle provide more effective arrangements of heating surface to insure thorough carbonization throughout the falling dust cloud, the illustration having been selected merely on account of its simplicity for purposes of explanation. The fine division of the coal in pulverized form permits rapid and thorough carbonization, permits the effective use of steam to aid oil and ammonium sulphate recovery, minimizes retort, power and heat requirements and delivers the solid fuel residue in a form suitable for subsequent pulverization if necessary with minimum expenditure of power. Judging from the coke made by this process which the author has seen it is believed that this could be burned in the furnace of the Fuller "Well" type just as it comes from the retort without further pulverization.

Processes of the second type employing cylindrical retorts in which the coal is stirred in contact with heated surfaces have been thoroughly tested in large scale operation in Europe. It is said that not a little of the motor spirits and lubricants used in German automobiles and

aeroplanes during the last year of the World War were manufactured from coal by this process as used by Thyssen, Stinnes and others in Germany, some of whose plants are still in operation in the Ruhr. The Fusion Corporation Limited, of England, has several of these plants in successful operation and is using the same type of plant for oil shale distillation in Esthonia.

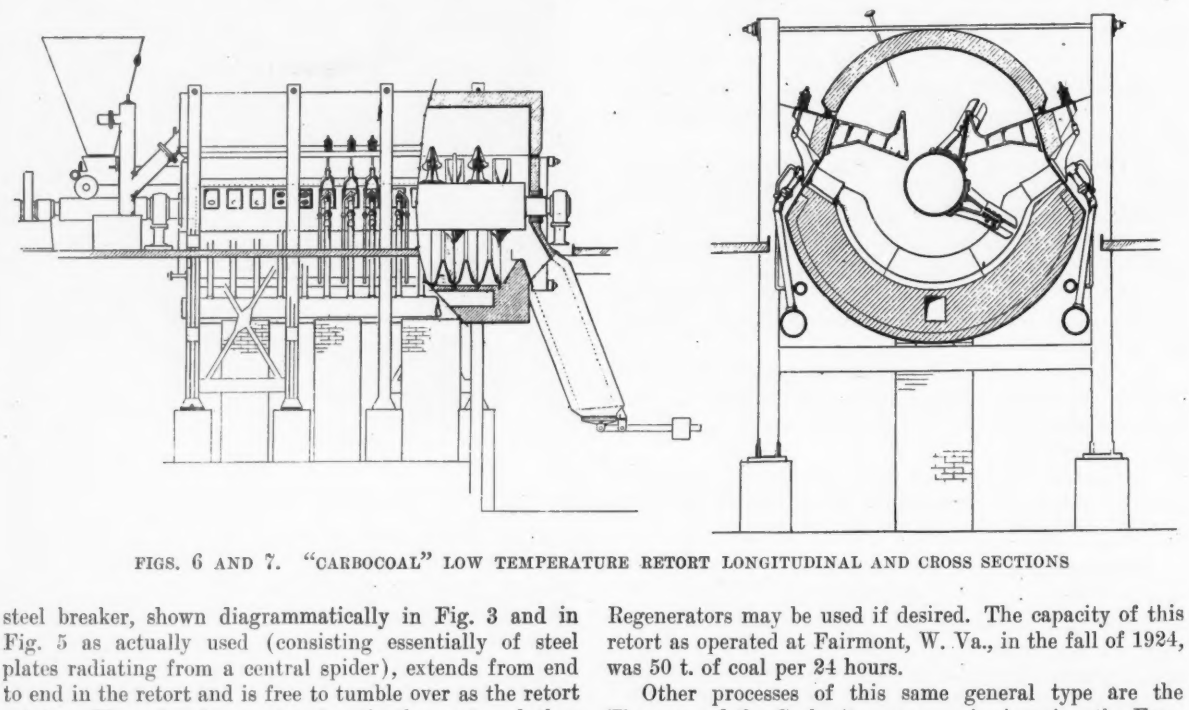
Unfortunately views are not available of the German externally heated rotary retorts from which best continuous commercial scale operating results have been obtained. The British "Fusion" rotary will therefore be described as typical of this class. The general layout of this retort and auxiliary plant is shown in Fig. 2. Figure 3 shows longitudinal and cross sections. Figure 4 shows the assembled unit ready for installation within the refractory heating chamber which surrounds it.

Coal enters the rotary retort through an automatic feed valve, passes through the retort tube where it is carbonized and is discharged at the other end through an automatic valve to the semi-coke hopper. To prevent sticking of the plastic coal on the retort walls a star-shaped steel breaker, shown diagrammatically in Fig. 3 and in Fig. 5 as actually used (consisting essentially of steel plates radiating from a central spider), extends from end to end in the retort and is free to tumble over as the retort rotates. These breakers not only stir the coal and thus constantly expose fresh surfaces to the hot walls but also give a hammering and chipping action on the sides of the retort, keeping it free from scale. The similarity of action to the cascading of material in a ball or tube mill is apparent. As a result the semi-coke contains a high percentage of fines suitable for combustion in pulverized fuel furnaces while the larger pieces can either be repulverized or sold as a domestic fuel.

The retort is heated with producer gas or the products of combustion of a hand or mechanically fired grate, the hot gases passing into the combustion chamber located on one side of the retort. Thence they pass to the heating chamber through a number of ports so placed and controllable at the chamber that the temperature of any part of the retort can be controlled. In this heating chamber the hot gases encircle the rotating retort spirally to produce counter-flow heat transfer, leaving the flue P of Fig. 3 in the bottom of the setting at the fuel entering end of the installation, thence to the stack. The retort is connected up with the usual type of condensing system for collecting oils and tar.

American Carbocoal retorts illustrated in longitudinal and cross section in Figs. 6 and 7 differ principally from that previously described in that the retort remains stationary while the motor driven shaft carrying arms with coal agitating paddles moving through the mass of coal and close to the heated surface, oscillates through an arc of about 270 deg. each 30 sec.

As shown in Fig. 7 the lower part of the retort consists of modified V or U shaped grooved sections of special heat resistant iron fitted together with flanges to break the joints. The upper part is a portion of the cylinder, built of light boiler plate covered with Silocel, which can be lifted bodily off the lower half for access to the shaft and paddles and the inside of the metal sections. The metal sections forming an efficient fin type heat transfer surface, are heated from below by burning producer gas.



FIGS. 6 AND 7. "CARBOCOAL" LOW TEMPERATURE RETORT LONGITUDINAL AND CROSS SECTIONS

Regenerators may be used if desired. The capacity of this retort as operated at Fairmont, W. Va., in the fall of 1924, was 50 t. of coal per 24 hours.

Other processes of this same general type are the Thomas and the Carbocite processes in America, the Freeman, the Pehrson and the Sensible Heat (Nielsen) processes in England and the Fischer and Glaud, the Fellner and Ziegler and the Raffloer processes in Germany, as well as several others, in which the charge is moved by screw or reciprocating conveyors which probably would not so well lend themselves to fine coke production for combustion in pulverized form.

Conservative primary yields averaged for several hundred tests of many kinds of coal approximate 20 to 30 gal. of crude oil, 2.5 gal. of crude motor spirits, 10 lb. of ammonium sulphate, 3000 to 4000 cu. ft. of 800 to 1000 B.t.u. gas, and 1500 lb. of coke per net ton of high volatile bituminous coal processed.

Computation of thermal efficiency based on above yields shows less than 85 per cent. Measurements made in actual practice by the British Fuel Research Board, Department

of Scientific and Industrial Research (1920-1921, second edition, p. 51, table 5) shows actual test thermal efficiencies ranging from 92.1 to 94.5 per cent. The yields quoted are obviously, therefore, most conservative, all difficulties incident to commercial operating practice having been amply discounted.

The investment cost of the complete plant including primary by-product recovery apparatus will range from $600 to $1,000 per ton day capacity (30 to 50 per cent of that of high temperature oven installations). The coke throughout is reasonably high, bears a high percentage of fines suitable for combustion in pulverized fuel furnaces, such as the Fuller "Well" furnace, with little, if any, subsequent pulverization. Carbonization and the major share of the pulverization are done simultaneously in one operation. The principal advantage of this general class of methods would appear to be that they have been in satisfactory continuous operation for sufficiently long that no unsuspected operating difficulties may be anticipated.

(To be concluded.)

Chemistry of Combustion of Pulverized Coal

HIGH VELOCITY OF BOTH AIR AND FUEL NECESSARY IN REMOVING INERT GASEOUS ENVELOPE SURROUNDING PARTICLES OF FUEL. BY S. C. MARTIN

PULVERIZED COAL is a solid fuel in a finely divided state and its combustion process, when it is burned in the furnace is similar to that of coal fired on grates and stokers.

The advantage derived from the pulverization of fuel is due to the fact that the subdivision of material into smaller pieces increases the superficial area that may be presented by a given volume. This increased area affords a greater extent of the surface of the fuel for the action of the air and the heat in the furnace, and results in more rapid completion of combustion, although the rate of combustion may not be greater.

Coal upon being heated in the furnace previous to its ignition separates into a solid and gaseous combustible, each of which requires different conditions of air supply within the furnace in order that it may burn most efficiently.

The gaseous combustible or volatile matter is of a complex nature, and its composition and the amount given off when the fuel is heated varies with the temperature and the rate of heating. The volatile matter contains incombustible gas as well as that which is combustible, the latter consisting principally of hydro-carbons.

Perfect mixing of air with the volatile before ignition is necessary for the rapid combustion of the gas; but the flame speed and length of the flame is not dependent alone upon a perfect mixture, for if either the air or the gas composing the mixture is in excess of the proper proportion for maximum flame speed the combustion will be slower. Moreover, the amount of air required for perfect combustion is not the same for different gases, and varying composition of the volatile requires a variation in the amount of air supplied if ideal results are to be approached. The presence of carbon dioxide in mixture with the gaseous fuel will exert a greater damping effect upon its combustion than will the presence of nitrogen. Speed of the fuel and air mixture entering the furnace and the manner in which it is admitted will affect the length of flame travel as will likewise the composition of the fuel.

Perfect mixing of the fuel and air will, if other conditions are favorable, aid in producing efficient combustion of the volatile constituent, but perfect mixing alone is not so effective in promoting combustion of the remaining solid portion of the fuel which consists principally of carbon in the form of coke, together with various incombustible minerals.

When a particle of pulverized coal enters the furnace it is enveloped in a film of air with which the volatile part of the fuel mingles when it is distilled off by the heat and in burning leaves the unconsumed solid combustible surrounded by inert gas from which it must emerge and while still at a high temperature, come into contact with air, if it is to be completely consumed.

Carbon in combining with the oxygen of the air forms carbon dioxide gas if the combustion has been completed,

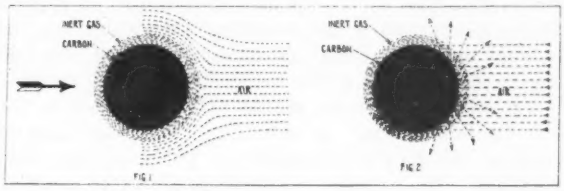


FIG. 1. AIR WITH LOW VELOCITY FOLLOWS PATH OF LEAST RESISTANCE

FIG. 2. HIGH VELOCITY AIR SWEEPS AWAY INERT GAS

and this gas must also be driven away from the surface of the fuel as fast as it is formed and replaced by pure air if the further combination of the oxygen with the carbon is to proceed with rapidity. It may be assumed that if air is not immediately available to drive away the carbon dioxide and furnish oxygen for continuing the combustion of the heated carbon, the gas will recombine with carbon to form carbon monoxide and thus delay the process.

A particle of solid combustible remaining in suspension in the furnace after the distillation and burning of its volatile will have its further combustion influenced by the manner in which it approaches and comes in contact with air; assuming that the fuel is at ignition temperature.

Should it enter with high velocity into air which is moving slowly or is at rest, its combustion will be less rapid than if, while either moving or stationary, the particle should come into contact with a current of air flowing with equal velocity in a direction opposed to it.

Assuming, for the purpose of illustration, a particle of fuel of spherical contour enveloped in a layer of inert gas, the scavenging action of the air in the two different methods of contact mentioned above may be assumed to be as shown in Figs. 1 and 2.

It will be noted that in Fig. 1, where the air has little or no velocity, it tends to flow in the path of least resistance and follows a stream line with little scavenging effect upon the gaseous envelope surrounding the carbon particle. In Fig. 2, where the air has force and direction by reason of its high velocity, the action on impact with the solid body is different and the air particles forcing their way

through the gaseous envelope and coming in contact with the surface of the carbon tend to drive away the gas as fast as it is formed.

This action of the air in accelerating the rate of combustion may be demonstrated by means of a lighted stick of wood, one end of which has been allowed to burn down to a glowing charcoal ember. By moving this ember rapidly through the air it will be noted that the combustion of the carbon is quickened. If, however, the coal is held stationary and a stream or current of air directed against it by means of a blow pipe, the fuel will be seen to burn away much faster than with the previous method of bringing it in contact with air. Accordingly, two conditions of air supply are necessary for the efficient burning of pulverized coal in the furnace, namely:

(a) For the gaseous constituent—perfect mixing with the proper amount of air.

(b) For the solid constituent—a blast of air impinging continuously on the solid particle until its combustion is completed.

Improper Use of Term "Turbulent Flow"

Mixing of the fuel and air in the pulverized coal furnace is facilitated by the condition referred to, in current articles on combustion, as turbulent flow, which may be described as a tumultuous agitation of the fuel, air, and gases at the burner or within the furnace.

Too much importance should not be attached to the term "turbulent flow" as indicating the direct cause of increased efficiency of combustion. Turbulent flow may be likened to the agitation produced in the water in a pool by stirring it with a stick in order to cause the sediment to rise and mix with the water.

In one sense it may be said that the agitation or turbulent condition causes the sediment to rise and mix, but the direct cause is the currents produced in the water by the stirring, and these currents in turn produce the turbulence. In the pulverized fuel furnace, turbulent flow may be induced by means of the force of a blast of fuel and air entering the combustion chamber or by an arrangement of opposed or impinging blasts; the difference in effect of the different methods being in the degree of violence of the turbulent condition and the direction of the currents produced.

Time, in addition to agitation or turbulence, is an element affecting the completeness of a gaseous mixture, and, since gases once mixed will not tend to separate, it may be assumed that a mixture of air and combustible gas will burn at any time and at any place in the furnace, provided the proper temperature conditions prevail.

In any turbulent flow it is not possible to predict or direct except in a general way the action of the air, the gases, and the solid particles, and the likelihood of a solid particle of combustible coming in contact with inert gas as it travels in the furnace is just as probable as that it will come in contact with air; and, although it may travel far enough and for a sufficient length of time to come in contact eventually with a sufficient amount of air for its combustion and be entirely consumed, yet, if all the solid particles should follow this same course, we should have a low rate of combustion. Scouring action of the inert gases against the carbon particle does not aid its combustion, for the scavenging must be accomplished by air if air is to come in contact with the fuel.

Since increased violence and cross currents in the turbulent flow increase the rate of combustion, it is probable that the velocity of the combustion air, which has the effect of an air blast against the carbon particle, is a factor in producing the result.

Directly opposed blasts of fuel and air have been successful in some cases in producing a high rate of heat liberation in industrial heating furnaces. The blasts meeting in the center of the furnace produce intense combustion and a high temperature.

Preheated air mixed with the fuel assists in raising the temperature to the point where the volatile is distilled off and, in this way, aids rapidity of combustion.

The combustion of pulverized coal in a furnace is not comparable in all respects to that of burning atomized liquid fuel in an oil engine cylinder for the reasons given above, namely: that coal before ignition separates in a gaseous and a solid combustible, one of which requires other conditions than perfect mixing with air in order to burn most efficiently. For the same reasons, this fuel cannot be said to burn entirely as a gas, although the interior of a furnace where there is rapid and complete combustion of the carbon, presents a transparent, incandescent appearance, similar to that of intense gaseous combustion.

Red Cross Is Active in Homes

Volunteer service has been called the life of the Red Cross and, in the Chicago district alone, during the year 1924, 1782 women volunteered for home service and gave time to making homes happier. The extent of the service is indicated by the expenditure of $89,604 during that year for the home service work.

Important also is the war work which has handled an average of 3300 cases a month, including hospital service, medical service to veterans in their homes, legal information and special services of various character.

Junior Red Cross work has enrolled 333,389 children of the schools and the first aid and life saving activities have interested over 5000 children and adults. Weekly talks on home hygiene have been broadcasted as well as occasional talks on first aid.

This is the work of only one of the 3000 chapters which are scattered over the country, each constantly serving for the benefit of those around them. The ninth annual roll call will be held from Nov. 11, Armistice Day, to Thanksgiving, when everyone will be invited to join in this great work. If you would help care for those whom disaster has made homeless, to show gratitude to the wounded veterans who fought for all of us, to help save life and promote health, to teach children to love and serve—if you believe that these things are worth while, that will be your opportunity to show it.

American Engineering Council is working for a bill to be enacted by Congress which will provide for a survey of the water-power resources of the country, under direction of the Geological Survey. Co-operation with federal, state or private agencies is proposed and an appropriation of $400,000 for the first year and $500,000 a year for 19 yr. following is incorporated, the survey to extend over a 20-yr. period.

Muscle Shoals has started delivering power, about 20,000 kw., to the lines of the Alabama Power Co.

Power House Heating and Ventilating*

COMPARISON OF PRACTICE OF SEVERAL LARGE CENTRAL STATIONS SHOWS GENERAL TRENDS IN DESIGN OF SYSTEMS

IN THE study of heating and ventilation, as installed in larger modern steam power stations, no uniform method of treatment is apparent, but the general trend in design is given in the following discussion. Main generators operate on a closed cooling system, thereby eliminating the discharge of large quantities of heated air into the turbine room which formerly caused excessively high room temperatures. Free circulation of air between turbine room and basement is assured by substituting galleries around the main units in place of a main operating floor. Natural ventilation is relied on, with little provision for heating except direct radiation adjacent to the windows, for the purpose of preventing window condensation. Roof condensation is prevented by insulated roof construction, the usual type consisting of a layer of insulating material between the roof slab and roof covering.

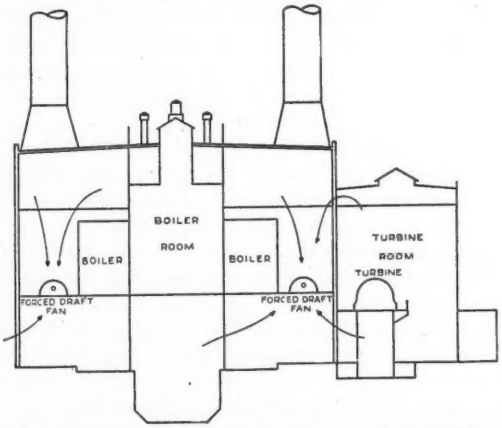


FIG. 1. CALUMET STATION TAKES VENTILATING AIR THROUGH TURBINE ROOM BASEMENT WINDOWS

Natural ventilation is relied on in the boiler room with a moderate amount of direction radiation at windows. Direct radiation is provided in the basement, where no radiation losses from equipment are present to temper the extreme low winter temperatures. In several instances the arrangement of the forced draft fans is such that they will withdraw air from the boiler room and, in a few cases, from the turbine room also, for the purpose of assisting the natural ventilation. Electrical control rooms are usually heated and ventilated by indirect heaters, fans and ducts, thereby keeping all steam and water piping away from the electrical control equipment. Offices, toilet and locker rooms, and other isolated rooms, rely on natural ventilation, and are heated by direct radiation.

VENTILATING THE TURBINE ROOM

While the ventilation of the turbine room has been carefully considered in several instances, many installations rely entirely on natural ventilation, by windows and roof ventilators, with results that are reported as adequate, apparently making any considerable expenditure to facilitate ventilation of questionable value. The tendency, in most of the larger stations, to operate the generator on a closed recirculation cooling system, eliminates the constant discharge of heated air into the turbine room, which in some of the older plants resulted in excessively high room temperatures.

Excessively high room temperature and poor ventilation, in the turbine room basements of older installation, have been avoided in modern plants, by eliminating the floor at the main operating level and by substituting galleries around the main units, resulting in unrestricted circulation of the air between turbine room and basement. The extensive substitution of motor-driven in place of steam-driven auxiliaries has also contributed to the lowering of the basement room temperature.

HEATING THE TURBINE ROOM

No uniform practice is apparent in the design of heating equipment for the turbine room, but the tendency seems to point toward the omission of all heating provision, except a current of warmed air at the windows, provided to counteract the cold down current. This is accomplished by wall radiators directly below the windows; or by indirect heaters, and ducts having slotted openings that cause a thin curtain of hot air to flow along the window surface. The heat dissipated by radiation losses from equipment and piping is sufficient, except in extreme cold weather, to result in a comfortable room temperature.

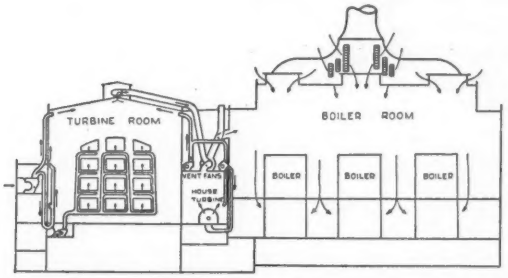


FIG. 2. AIR FROM INDIRECT HEATERS SWEEPS INTERIOR SURFACE OF TURBINE ROOM WINDOWS AT TRENTON CHANNEL

From the meager data that have been received showing actual results, it appears that more heating surface is usually installed in the turbine room than is required and that, with no heating provision except at the windows, the turbine room would be at a comfortable working temperature most of the time, and only moderately cool in extreme cold weather.

Roof condensation has been entirely eliminated in most modern plants by the installation of some form of roof slab incorporating an insulating material which will greatly retard transmission of heat from the inside to the outside air. A layer of cork, hair felt or equivalent, laid on the roof slab and covered with the usual roof covering, has proved entirely satisfactory. The elimination of steam auxiliaries and piping and the elimination of the open discharge from the steam gland seal on the main units, have greatly reduced the cause, and therefore the liability, of roof condensation, but the installation of roof insulation over the turbine and electrical rooms is becoming universal, in order to allow for extreme and emergency conditions.

*Abstract of report for 1924-1925 on "Power House Heating and Ventilating," issued by the Prime Movers' Committee of the N. E. L. A.

Heating and Ventilating the Boiler Room

No uniformity exists in the design of heating for the boiler room, as the particular arrangement of boiler room and basement, fans, ducts and ash disposal equipment makes each design a separate problem. Usually, however, some direct radiation is supplied at the windows on the main operating floor, and sufficient radiation is supplied in the basement to give a working temperature well above freezing in extreme cold weather.

The practice in the past of taking the air for the forced draft fans from the ash tunnel, and other portions of the boiler room basement resulted at times in basement room temperatures sufficiently low to expose the water piping to freezing. The tendency, now, is to provide a special entrance for the air for the forced draft fans, isolated from the remainder of the basement.

Several modern plants obtain a part of the supply for the forced draft fans by withdrawing the air from the boiler room, either from definite points, by means of ducts, or by natural circulation, through grating floors; and in some instances this has been supplemented by openings into the turbine room with arrangements made for supplying fresh air from outside of the turbine room. The latter arrangement apparently fills all requirements for turbine and boiler room ventilation, but requires ample indirect heating equipment for the fresh air entering the turbine room in order to avoid low turbine room temperatures in extreme cold weather.

The general tendency appears to favor withdrawing the air from the turbine room from near the ceiling instead of from the basement. The two methods are probably equally effective in winter; but in summer, removing the air from near the ceiling would help to keep the room temperature down.

The large quantities of air required by the forced draft fans insure frequent change of air with slight additional expenditure of power.

Practice Varies in Control Room Heating

The electrical control room must be dry and at a comfortable working temperature at all times; which provision has precluded the use of direct radiation in favor of indirect heating, fans and ducts. Several large modern plants, however, are using direct radiation in this part of the plant with apparently acceptable results. The expense of the forced ventilation system seems to be warranted, in order to avoid the danger of trouble caused by leaking of water and steam from pipes located in the control rooms. The forced ventilation system has the further advantage of being able to clear the rooms quickly of smoke and gases in case of emergency.

Isolated rooms, such as offices, toilet and locker rooms, shops, storerooms and hallways, rely almost universally on natural ventilation and are heated by direct radiation, conforming in amount to usual heating and ventilating practice, the room temperature depending upon the use for which the particular room is assigned.

Details of Methods Used by Various Large Stations

In the accompanying tabulation appear data on the various methods of heating and ventilating employed by 12 typical central stations. A detailed discussion of some of these methods is given below:

Calumet Station of the Commonwealth Edison Co., has no provision for heating the turbine or boiler room. Direct radiation is supplied in the electrical control rooms and in the offices, toilet and locker rooms.

Fresh air enters the windows in the turbine room basement and is drawn into the boiler room through openings in the division wall at the basement and at the roof levels, as shown in Fig. 1. The forced draft fans draw air from the boiler room, gratings in the floor allowing

TABLE SHOWING HEATING AND VENTILATING METHODS USED BY 12 LARGE CENTRAL STATIONS

STATION	CALUMET	ESSEX	KEARNEY	NEOSHO	TRENTON CHANNEL	CAHOKIA	WAUKEGAN	HALES BAR	DEVON	WEYMOUTH	SOMERSET	WABASH RIVER
COMPANY	Commonwealth Edison Co.	Public Service Electric Co.	Public Service Electric Co.	Kansas Gas & Electric Co.	Detroit Edison Co.	Union Electric Light & Power Co.	Waukegan Generating Co.	Tennessee Electric Power Co.	Connecticut Light & Power Co.	Edison Electric Illuminating Co.	Montaup Electric Co.	Indiana Electric Corp.
LOCATION	Chicago, Ill.	Newark, N.J.	Newark, N.J.	near Parsons, Kan.	Trenton, Mich	St. Clair Co. Ill.	Waukegan, Ill.	Ladds, Tenn.	Devon, Conn.	Weymouth, Mass.	Fall River, Mass.	Terre Haute, Ind.
HEATING Turbine Room	None	None	Blower-heater units	None	Indirect rad. for windows & roof	Direct rad.	None	None	Direct rad.	Direct rad. at windows	Direct rad. at windows	Direct rad.
Boiler Room	None	None	Blower-heater units	None	Direct rad.	Direct rad.	Direct rad.	None	Direct rad.	Direct rad	Direct rad.	Direct rad.
Elec. Control Rooms	Direct rad.	Direct rad	Direct rad.	Direct coils	Direct rad	Direct rad. in Control Room	None	None	Direct rad. in Control Room	Indirect rad.	Indirect rad.	Indirect rad.
Offices	Direct rad	Direct rad.	Direct rad	Direct coils	Direct rad	Direct rad.	Direct rad.		Direct rad.	Direct rad.	Direct rad.	Direct rad.
GEN. COOLING SYSTEM	Closed	Closed	Closed	Discharge up into room	Closed	Closed	Discharge up into room	Closed	Closed	Closed	Closed	Closed
TURB. RM. ROOF CONDENSATION	Insulated Practically None	Not Insulated Yes	None Expected	4" Gypsum Ins. None	Not insulated None expected	2" Cork ins. None	Hair felt ins. None	None None	Not insulated None	2" Lith. ins. None expected	2" Lith. ins. None expected	2" Lith. ins. None expected
VENTILATION Turbine Room	Enters windows Drawn out by forced draft fans.	Natural	Natural	Natural	Fans & Duct to sweep windows & roof. Drawn from monitor	Natural	Natural	Drawn along ceiling to Boiler Room	Natural	Natural	Natural	Natural
Boiler Room	Drawn to fcd. draft fans	Natural	Natural	Natural	Enters from turbine room & around flue	Enters from windows & from turbine room.	Natural	Drawn to fcd. draft fans	Drawn to fcd. draft fans	Natural	Drawn to fcd draft fans	Natural
Electrical Cont. Rooms	Ducts to roof Fans & ducts	Natural	Fans & ducts	Natural	Exhaust fans	Fans & ducts	Natural	Natural	Natural	Fans & ducts	Fans & ducts	Fans & ducts
Offices, etc.	Natural	Natural	Natural	Natural	Natural	Natural	Natural	Natural	Natural	Natural	Natural	Natural

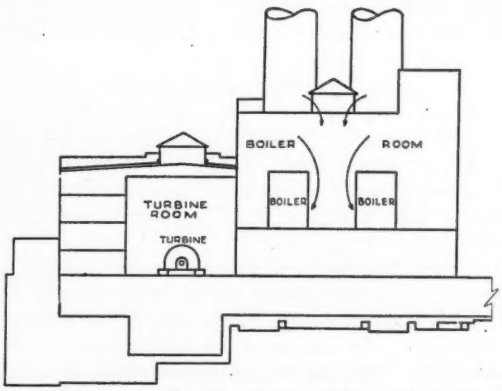


FIG. 3. CAHOKIA STATION USES DIRECT RADIATION AND NATURAL VENTILATION

free circulation down to the fans. The general circulation is shown in Fig. 1. The electrical control bay has ducts to the roof with natural ventilation, with fans and ducts for the reactor and oil switch floor. The insulated turbine room roof results in practically no roof condensation.

Trenton Channel Station of the Detroit Edison Co., has no direct radiation in the turbine room, but supplies air through indirect heaters and ducts to sweep the interior surface of windows and ceiling with currents of hot air. Direct radiation is installed in all other portions of the building.

Air is withdrawn from the turbine room monitor by means of fans and ducts, and discharged into the boiler room. Air is drawn down by free circulation through the boiler room to the forced draft fans, provision being made for the entrance of additional air from the roof around the flues. The electrical control rooms are provided with exhaust fans, while offices and toilet room rely on natural ventilation. The general circulation is shown in Fig. 2. The roof of the turbine room is not insulated, but it is expected that roof condensation will be eliminated by the currents of hot air provided to sweep the ceilings.

Cahokia Station of the Union Electric Light and Power Co. has direct radiation throughout the building. Natural ventilation, by windows, is relied on in the turbine room, and the air in the boiler room is supplied through windows and drawn down by natural circulation to the furnaces, as shown in Fig. 4. The electrical control rooms are provided with fans and ducts. The turbine room roof is provided with cork insulation, which has prevented roof condensation.

At the new Weymouth Power Station* of The Edison Electric Illuminating Co., of Boston, the heating and ventilating system has been made as simple as considered feasible, both from an operating and an installation point of view. Natural gravity, unassisted by fans, has been used to considerable extent. Direct radiation, operating on a simple gravity return system, has been used except where, for electrical safety reasons, an indirect air system is preferable.

The entire plant, including outbuildings, is heated from a central point with a system of distributing supply and return lines supplied with steam at 5 to 10 lb. pressure. The steam is normally supplied from one of the few

*In a paper entitled "Heating and Ventilating of a Modern Steam Power Station," by D. S. Boyden and A. B. Williams, presented at the 1925 annual meeting of the A. S. H. & V. E., the heating and ventilating system of Weymouth station was discussed in detail. An abstract of this paper appeared in the March 1, 1925, issue of Power Plant Engineering.

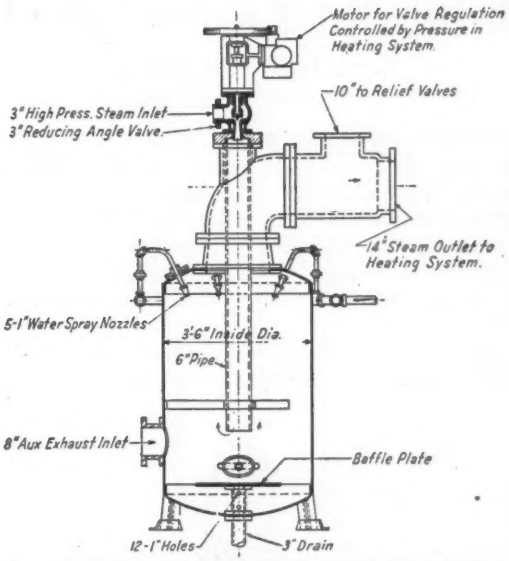

Motor for Valve Regulation Controlled by Pressure in Heating System.
10" to Relief Valves
3" High Press. Steam Inlet
3" Reducing Angle Valve
14" Steam Outlet to Heating System.
5-1" Water Spray Nozzles
3'-6" Inside Dia.
6" Pipe
8" Aux Exhaust Inlet
Baffle Plate
12-1" Holes
3" Drain

FIG. 4. AUTOMATICALLY OPERATED REDUCING VALVE AND DESUPERHEATER SUPPLIES LIVE STEAM AT WEYMOUTH TO SUPPLEMENT EXHAUST FROM SMALL TURBINE

steam-driven auxiliaries—a small turbine driven generator. When necessary this source of supply is supplemented by live steam taken from the 350 lb. system and reduced to 10 lb. by a special motor-driven valve, shown in Fig. 4. This valve, automatically controlled by the pressure in the heating system, begins to open when the pressure in this system has dropped to 7 lb.

The heating system is laid out on the two-pipe principle, with thermostatic traps on the return end of the radiating fixtures. There are no vacuum return pumps, the water in the return piping flowing back by gravity to the power station distilled water tanks, where it is returned to the main feed system. The turbine room is heated by direct radiation placed under the windows. Turbine room, boiler room, and equipment have been laid out to give free circulation of air and utilize natural gravity for ventilation.

Portions of the building containing "live" electrical equipment are heated in winter and cooled in summer by a system of vertical supply and exhaust ducts. The exhaust fan on the roof is used for extreme heat conditions and also to hasten the removal of smoke in event of a fire or short circuit. The roof of the turbine room is provided with "Lith" insulation, which is expected to prevent roof condensation.

ELECTRICAL WORKERS whose duties require them to work in the proximity of "hot" conductors should be cautious of what appear to be non-metallic measuring tapes. As reported in a recent issue of the Detroit Edison "Synchroscope," a measuring tape almost caused a fatal accident to an employe of an eastern utility recently. The employe stood on the steel framework of an outdoor substation and attempted to measure the distance between the topmost part and the ground when the wind blew the tape over a live bus, resulting in a severe electric shock and a fall of 30 ft. to the ground. This tape was a conductor, being manufactured of woven fine copper wire and thread. The tape itself, upon examination, is innocent looking and the copper wire would not be found or noticed unless the outer protective coating is scraped off.

British Apply Lentz Valve to Bi-Flow Engines

By F. Johnstone-Taylor

AT THE PRESENT TIME there is a tendency to decry the advantages possessed by slow-speed steam engines. Naturally, with the oil engine on the one hand and the steam turbine on the other, the field of application of the reciprocating engine is becoming limited and, to retain its supremacy even in its most useful sphere, designers have had to consider means for increasing its efficiency.

Application of the uniflow principle has undoubtedly helped to maintain interest in the slow-speed steam engine,

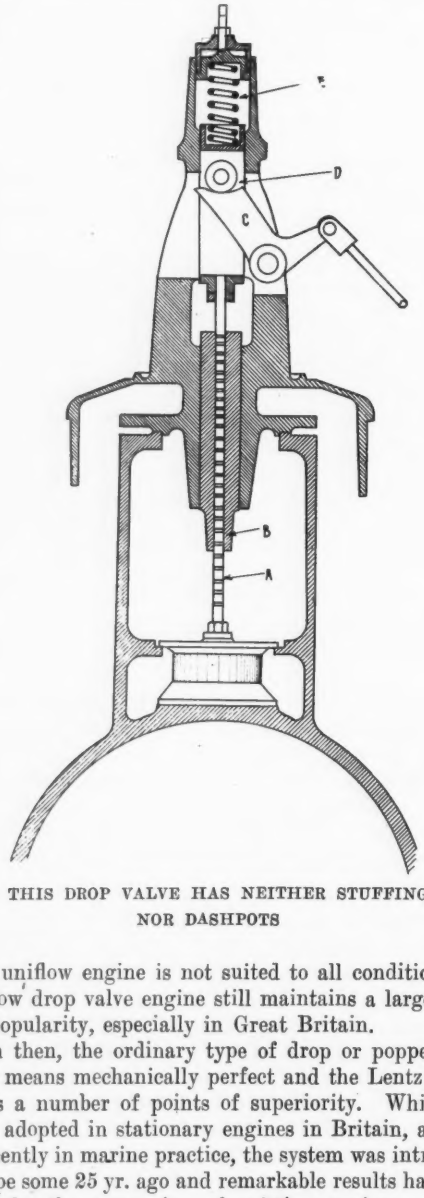


FIG. 1. THIS DROP VALVE HAS NEITHER STUFFING BOXES NOR DASHPOTS

but the uniflow engine is not suited to all conditions and the bi-flow drop valve engine still maintains a large measure of popularity, especially in Great Britain.

Even then, the ordinary type of drop or poppet valve is by no means mechanically perfect and the Lentz system possesses a number of points of superiority. While only recently adopted in stationary engines in Britain, and still more recently in marine practice, the system was introduced in Europe some 25 yr. ago and remarkable results have been obtained by the conversion of existing engines. It has also been successfully applied to locomotive work. In fact, this type of valve is applicable to almost any type of steam engine; it has the advantages of simplicity and positive, silent action, and it is suited to speeds considerably in excess of those at which trip gears will function satisfactorily.

As applied to large slow-speed engines of the mill class, the essential features of the system are shown in Fig. 1. The first point to note is that there are no stuffing boxes, the valve spindle A being ground to fit in bushing B, the grooves on the spindle forming a labyrinth packing. Neither is there the usual dashpot as associated with the ordinary type of drop valve.

The valve is raised by the same lever C acting upon the roller D, this lever being moved by an eccentric. The gear is practically noiseless, as the roller D is always kept in contact with the cam lever during the travel by means of spring E. This cam does not move clear of the roller until after the valve is seated, so that even at relatively high speeds there is neither noise nor hammering. Thus the dashpot is eliminated and rapid closing of the valve is insured. The motion is entirely positive, the profile of the same insuring the necessary rapid seat.

As at present arranged, the engines built in Great Britain under the Paxman Lentz designs employ a side shaft governor of the inertia type. This is shown in Fig.

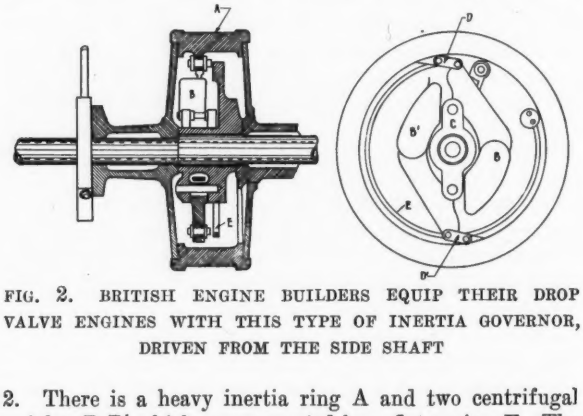


FIG. 2. BRITISH ENGINE BUILDERS EQUIP THEIR DROP VALVE ENGINES WITH THIS TYPE OF INERTIA GOVERNOR, DRIVEN FROM THE SIDE SHAFT

2. There is a heavy inertia ring A and two centrifugal weights B B′ which are connected by a flat spring E. The two weights B B′ are fitted to carrier C, which is fixed to the side shaft, both weights and carrier being attached to the inertia ring, which acts as a flywheel. This attachment is effected by the knee joint formed by D D′. It will be seen that any alteration of speed is counteracted by the inertia of A, the motion of which moves the carrier, actuates the eccentrics and thus alters the cutoff.

Revision of the Illuminating Engineering Nomenclature and Photometric Standards has been approved by the American Engineering Standards Committee as "American Standard." The work includes the definition of terms used in illuminating engineering and photometry, together with the formulation of general principles to govern the measurement of light and illumination and the application of such measurements in practice.

Definition of the "Lambert," which is the unit for brightness, together with those of a number of other units used in light measurements, have been retained as previously given. Conversion factors for various working units are given. This work, under the sponsorship of the Illuminating Engineering Society, was carried out by a sectional committee containing representatives of various engineering organizations. The chairman of the committee is E. C. Crittenden of the Bureau of Standards.

Wabash River Station Employs Holly Loop

PLANT OF INDIANA ELECTRIC CORP. REPORTS SATISFACTORY AND ECONOMICAL USE OF SYSTEM FOR DIRECT RETURN OF CONDENSATE TO BOILERS. BY J. L. PEURIFOY*

TO CARE for the high pressure drip returns at the Wabash River Station, Dresser, Ind., the Holly loop is employed, this layout having been incorporated in the original design of the general piping for the plant. This system, which can reasonably be termed foolproof, requires little attention and the return of the condensate from the various high pressure drips on the main and auxiliary steam headers back to the boiler shells proper is practically assured.

Figure 1, an isometric piping diagram of the Holly loop as installed at this plant, shows clearly the general principles involved in the design and operation of this equipment. Although most engineers are familiar with the fundamental principles on which the Holly loop operates, a brief discussion of them here may prove helpful. The apparatus is essentially a boiler connected to a closed vessel, called the discharge chamber, by two pipes; one pipe, called the riser, is connected through the receiver to the steam space of the boiler and the other, called the return, to the water space. Under this condition the water in the return stands at the same level as that in the boiler, because the pressure in the discharge chamber equals that in the boiler.

If the pressure in the discharge chamber is lowered by some suitable means (in practice, by venting the discharge chamber), water will rise in the return to such a height that the added weight of water will balance the difference in pressure between the boiler and the chamber, and steam will flow through the riser in an effort to balance the pressure. Any water carried by the steam will be swept along and delivered into the discharge chamber, where it falls to the bottom and enters the boiler through the return, as long as the added weight of water is greater than the difference in pressure between the boiler and the chamber.

It will be noted, in Fig. 1, that the respective drip lines from the main steam header discharge into the main receiver, whereas the drips from the auxiliary headers discharge directly into the Holly receivers. In this connection it is likewise to be noted that a bronze orifice, shown in Fig. 2 A, is provided in the discharge line connecting the main receiver to the Holly receivers. This feature of design permits the safe and positive operation of this system regardless of the steam demand on the auxiliary header. This demand, if excessive, as in the case of starting emergency steam driven equipment, such as boiler feed pumps and fire pumps, might cause such a fluctuating load as to produce a decided pressure drop in the auxiliary header. This might permit the condensate to back up through the Holly receivers into the auxiliary header, thereby water-logging the header, cutting off the supply of steam to the steam driven auxiliaries, and resulting in a serious interruption to the station service. By passing the condensate from the main receivers to the Holly receiver through the orifice, we are able to regulate the amount and prevent this condition.

In this system, the discharge chamber is mounted on the outside of our No. 1 stack, the center line of the discharge chamber being approximately 40 ft. above the roof. This elevation affords a 48-ft. head on the boiler drum which corresponds closely to a pressure head of 20 lb. per sq. in. gage.

A 2-in. riser conducts the high pressure drip condensate from the Holly receiver to the elevated discharge chamber. In addition, a 3-in. return line from the discharge chamber is provided for carrying the condensate, which has been elevated to this level, back to the boiler where it is introduced into the boiler shell proper just below the water line. The ¾-in. vent line, which is tapped into the top of the discharge chamber, is vented into the surge tank through the fitting shown in Fig. 2 B. This surge tank is connected with the main boiler feed system.

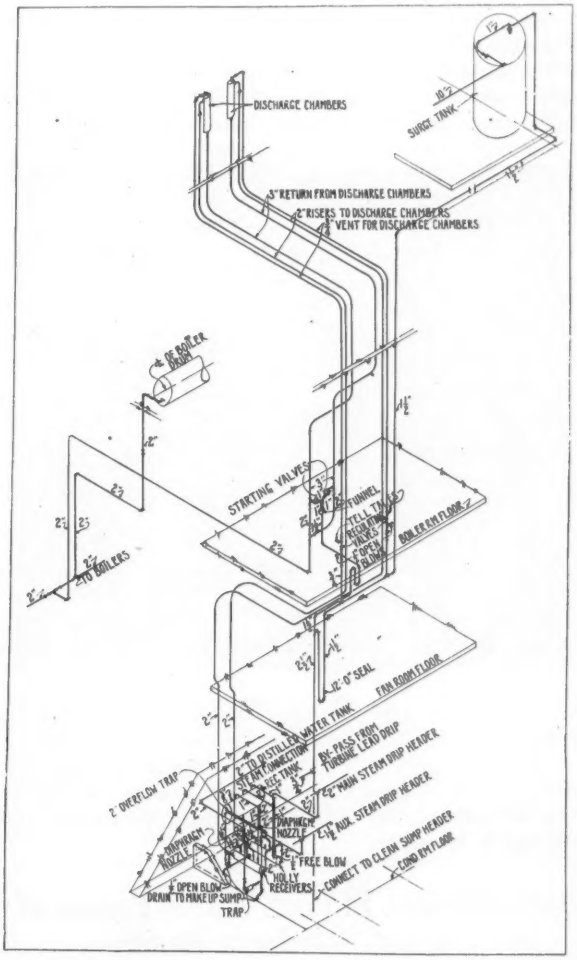


FIG. 1. DETAILS OF HOLLY LOOP AS EMPLOYED AT WABASH RIVER STATION

The method of operation can be outlined as follows:

After the starting valves have been opened and steam appears, the ¾-in. vent line from the top of the discharge chamber is vented through a Fisher reducing valve, marked regulating valves in Fig. 1, which is throttled to approximately 5 lb. gage pressure on the low side. The discharge from this vent line is piped to the surge tank. Since the entire system is under header pressure, the effect of venting

*Chief Operating Engineer, Wabash River Station.

the discharge chamber is to reduce the pressure at this point. This pressure drop is maintained to such a degree as to insure a positive circulation of the condensate from the Holly receivers up to this point. The collected condensate in the discharge chamber, while under boiler pressure, exerts at the same time an additional static head due to its elevation, this static pressure will overcome the drop across the horizontal swing check valve in this line, thereby forcing the condensate into the boiler drum. With the proper vent pressure being maintained, this cycle is continuous in its operation.

In case the Holly loop system should become inoperative or should be taken out of service for routine maintenance and repairs, a provision is made, whereby the high pressure condensate is bypassed around the system proper. Under these conditions the condensate is taken care of by a 2-in. high pressure Squires trap which discharges directly into the distilled water tank. When following this method of operation the condensate which is introduced into the distilled water tank flows by gravity into the clean water sump, where it is picked up by the clean water sump pump

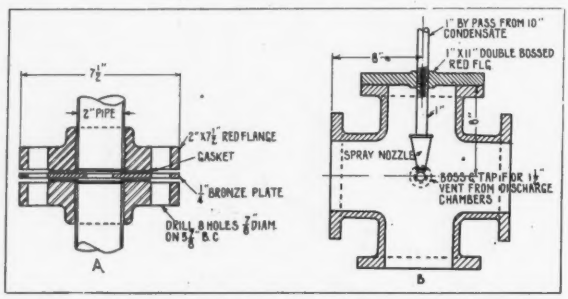


FIG. 2. A—DETAILS OF DIAPHRAGM NOZZLE WHICH REGULATES CONDENSATE FLOW FROM MAIN RECEIVER TO HOLLY RECEIVERS. B—DETAILS OF VENT CONNECTION AT SURGE TANK

and then discharged to the overhead surge tank, from which it is introduced into the feed water system proper.

As previously stated, we have experienced little difficulty in the operation of the Holly loop as installed at this station and feel that it has proved economical and efficient in operation.

Government Studies Water Power of Great Salt Lake Basin

In 1900 the installed capacity of the water-power plants in the Great Salt Lake Basin was about 14,000 hp.; in 1923 it was more than 225,000 hp. These are two of many interesting facts shown in Water Supply Paper 517 on the water powers of the Great Salt Lake Basin, published by the Geological Survey, Department of the Interior. The total capacity of undeveloped sites in the Great Salt Lake Basin is 81,000 hp. for 50 per cent of the time and 56,000 hp. for 90 per cent of the time with existing flow, and 115,000 hp. for 50 per cent of the time and 80,000 hp. for 90 per cent of the time with regulated flow.

Developed and undeveloped sites in the basin are described in the report, which also gives such information relative to the use of water in irrigation and to the market for power as will afford a basis for a correct estimate of the present and future value of the water-power resources of the basin and of the possibilities for profitable water-power development.

Condenser Cleaning

By C. M. Griffin

MOST economical vacuum for any installation depends upon a number of variables among which are the design of the units and the quantity and quality of the circulating water. The maximum practical vacuum is, of course, limited by the temperature of the circulating water and, for this and other reasons, the most economical vacuum for an installation will vary with the seasons.

Considering only the larger units, however, with an unlimited quantity of circulating water, the maximum practical vacuum, or the "guaranteed vacuum," is practically constant and should be for the various circulating water temperatures about as given by the curves herewith.

When it is clean, air tight and otherwise all right, a condenser should produce guaranteed vacuum or better; the writer believes that just how closely the most economical vacuum approaches the maximum vacuum depends upon the method of cleaning more than anything else, consequently upon the cost of cleaning as compared with the

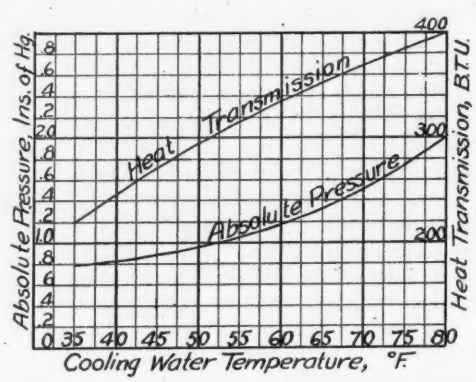


FIG. 1. RELATION OF COOLING WATER TEMPERATURE TO VACUUM POSSIBLE

results obtained. If a condenser can be cleaned thoroughly in a short time and at a small cost, the most economical vacuum for it will approach closely the maximum possible vacuum.

Just how a condenser should be cleaned depends upon the nature of the deposits in the tubes. These deposits will vary with the source of the circulating water, its velocity through the tubes, previous methods of cleaning and with the temperature of the circulating water and the seasons.

Usually, where condenser cleaning is a large problem, the deposits collect more or less rapidly in the tubes, especially during the summer, and shooting rubber plugs through the tubes with compressed air has become a common method of cleaning them. In most cases, however, a more effective cleaner must be used at least part of the time, or scale will form in the tubes, which will reduce the efficiency of the condenser and promote corrosion of the tubes.

Where the circulating water velocity is kept up to 6 ft. per second or more, any deposits that collect in the condenser tubes must adhere more or less tightly to them and a cleaner propelled by a small force must have sharp cutting edges that do not clog, if it is to clean a tube thoroughly on passing through it only once.

Ability of a cleaner to dislodge tightly adhering deposits, when it has no cutting edges, depends upon its

loosening them by abrasion as it slides over them. It cannot push anything ahead of it, except loose and soft deposits. A plug that is harder and more abrasive than the ordinary one of soft rubber will no doubt do more cleaning than a soft one but, like the soft plug, if it has no cutting edges, its ability to dislodge deposits that adhere tightly to the tubes is limited by its loosening effect as it slides over them.

If the surface of the condenser were flat and readily accessible, the writer believes that anybody would choose a scraper for cleaning it, especially if it was required to clean a large surface thoroughly and quickly with only one stroke and with a limited force. In cleaning condensers you have smooth surfaces that are most efficiently cleaned by scraping, provided, of course, that you can get scrapers that conform closely to the surfaces and can be effectively and readily applied.

Whether or not cleaning preserves the tubes has been a subject of much discussion and, where the life of the tubes is short, it is an important consideration. Usually

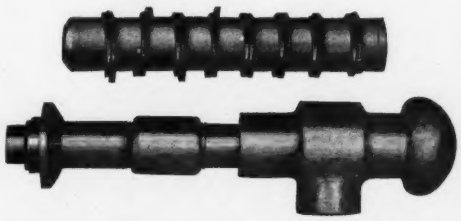


FIG. 2. SCRAPER TYPE CLEANER IS SHOT THROUGH CONDENSER TUBES BY SPECIAL NOZZLE WITH VALVE OPENING AUTOMATICALLY WHEN NOZZLE IS PRESSED INTO END OF TUBE

it is conceded that proper cleaning does preserve the tubes and, if it does, smooth sharp scrapers that clean them thoroughly and keep their surfaces smooth should preserve them to the greatest extent.

One might think that sharp steel scrapers would soon wear a thin brass tube away but such is not the case. It is, of course, quite possible to cut a brass tube with a steel scraper, if enough force is applied; but, with the small force and the comparatively wide surface incident in cleaning condensers, it is impossible to cut the tubes. Actually the problem is to get the scrapers to bear hard enough against the tubes and to scrape them enough to clean them, rather than to keep them from cutting the tubes.

One cleaner having sharp steel scrapers intended for shooting through the tubes with water, together with a valve and nozzle for applying the water, are shown in the accompanying illustrations. The construction of this cleaner is such that it is rugged, yet flexible; it enters the tube readily, conforms closely to its surface and can accommodate itself to large variations in the size and roundness of the tubes.

Some might balk at the idea of using water for shooting the cleaners but, with proper equipment, it is used without difficulty. Water shoots the cleaners at a much lower speed than does air and cleaners, especially of the scraper type, will give better service when shot with water. When cleaners like the one shown are shot with water, no provision for catching or protecting them is necessary. They can be shot against the iron head of the condenser and allowed to fall in a pile without injuring them.

Large condensers may be cleaned without taking off the heads but, when properly equipped for it, large heads can be lifted in a short time and it pays well to do it. The writer knows of 50,000 sq. ft. compartment type condensers that are cleaned every few days during the summer, the heads being lifted for every cleaning, whether it be with rubber plugs or with the scraper type of cleaner.

There is no reason why the heads of a condenser cannot be made so that they can be readily lifted. They usually are required to hold only low pressures and it is not necessary to draw the bolts up very tight. The right kind of a gasket can be used many times on such service.

The water box of a condenser is at best a disagreeable and cramped place in which to work and there is nothing that will help so much toward making the condenser cleaning job an easy one as lifting the head.

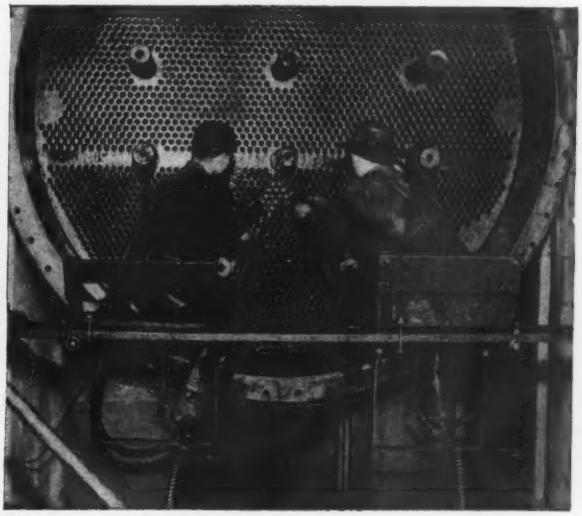


FIG. 3. BY REMOVING CONDENSER HEADS AND USING A CONVENIENT PLATFORM, CONDENSER CLEANING IS MADE COMPARATIVELY EASY

A good and convenient scaffold that is quickly and easily set up and adjusted also contributes to the success of the condenser cleaning job. The accompanying illustration shows two men cleaning a condenser with a convenient and advantageous equipment.

ELECTRICITY is responsible, perhaps more than any other thing, for improved methods of building construction, making easier the burden of our workers and decreasing costs of production. The A. S. M. E. and others interested predict that the din of the steel riveter on building girders may soon give way to the flame of the electric arc, and the steel skeleton of the future skyscraper may be a single, welded unit. Decreased cost, greater strength and lighter materials are all factors in the welded building that will, it is said, bring about the adoption of the new method of erection. Steel parts will be cut to pattern, much as a tailor cuts the parts of a coat, but without the necessity for the precise accuracy needed when lines of rivet holes must be matched. The cost of drilling thousands of rivet holes will be saved; the strength of an arc weld is equal to that of the parts welded, and a welded joint is impervious to water, oil or gas, while the expense of welding is said to be only three-fourths that of riveting.

Diesel Engines Replace Steam at Clinton, Okla.

RAIN WATER USED TO COOL ENGINES AND FUEL OIL IS HEATED BY EXHAUST GAS

RECENTLY, the Clinton, Okla., plant of the Oklahoma Gas & Electric Co. has been changed over from power generated by steam to generation by means of Diesel engines. One of the most interesting features of this plant is the fact that rain water is used for cooling the engine cylinders and this water in turn is cooled in a heat exchanger, water for which is obtained from a spray pond. 15 per cent, was used after passing it through an evaporator. The boiler and engine equipment have been put in such shape that it can be operated should occasion demand. The main units in the plant now are two three-cylinder Worthington Pump & Machinery Corp. air injection Diesel engines.

The size of these engines is designated as 17 by 25 in.

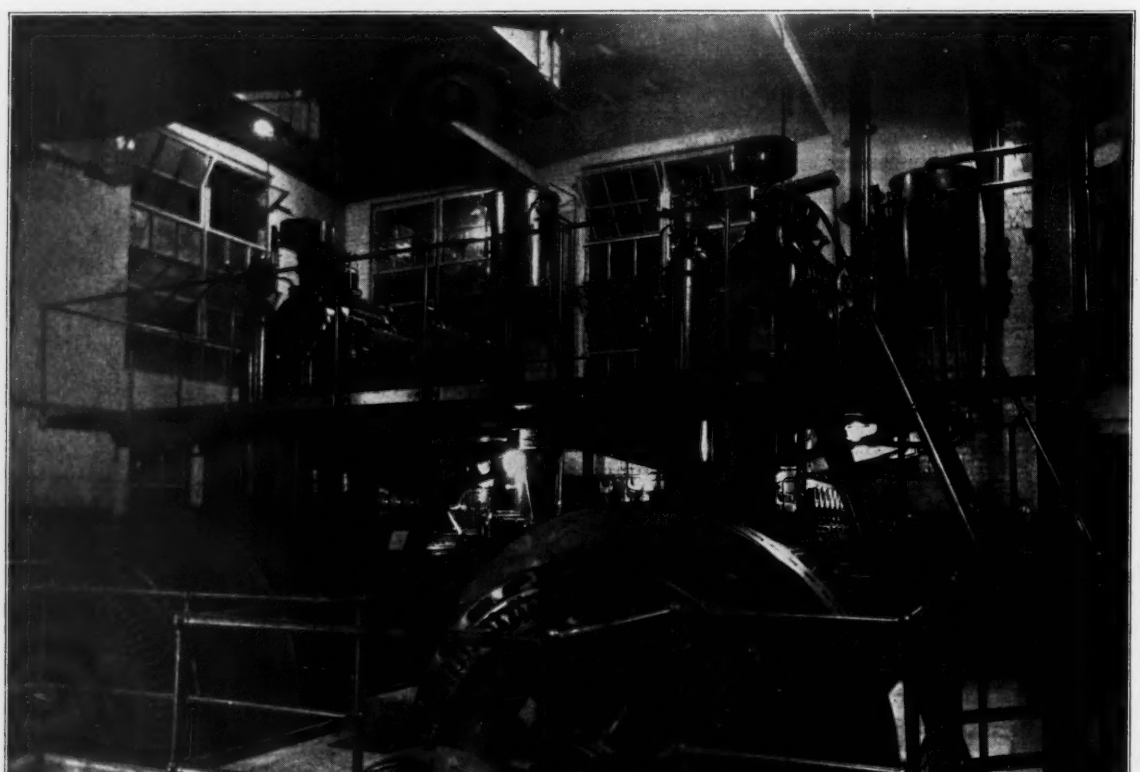


FIG. 1. WORTHINGTON DIESEL ENGINES DIRECT CONNECTED TO GENERAL ELECTRIC GENERATORS

The old steam plant consisted to two water-tube boilers which were fired by oil. In the engine room was a cross-compound Corliss engine, direct connected to an alternator and the exciter was belt connected to the engine shaft. There was also a single cylinder steam engine belt connected to an alternator, the exciter being belt driven from the alternator shaft. Both engines were connected to one surface condenser, water for which was obtained from a spray pond. This condenser was not large enough for both engines to be operated, condensing at the same time.

Make-up water for the spray pond was obtained from the river. Boiler make-up water, which generally ran over and each is direct connected to a General Electric Co. alternator, which is rated at 200 kw., 80 per cent power factor, 200 r.p.m., 3 phase, 60 cycle, and 2300 v. An 11-kw., 125-v. exciter is direct connected to each engine shaft.

Fuel oil is stored in two steel underground tanks, the capacity of each being 40,000 gal. Oil is delivered in tank cars. Oil is pumped from these tanks to two overhead tanks, located near the engines. The pumps are Faber Pump Co. rotary type, each being driven by a 220-v., General Electric Co., induction motor through one pair of spur reducing gears. The oil then flows by gravity to the fuel oil pumps on the engines. This oil piping is so arranged

that either pump may discharge to either overhead tank and either engine may be supplied with oil from either of the tanks.

As previously mentioned, rain water is used for cooling the engine cylinders. This water is drained to an underground cistern, which is provided with an overflow to an old boiler shell buried under ground. This shell is not connected to the circulating system, but is used as an emergency storage for rain water.

Rain water is drawn from the cistern by two Chicago Pump Co. centrifugal pumps, each rated at 180 g.p.m., 1700 r.p.m. and 35 ft. total head. Each pump is direct connected to a Western Electric Co., 7½-hp., 220-v., induction motor. The water first passes through The Whitlock Pipe Coil Co. heat exchanger and is discharged into two water tanks located on the roof. It then flows by gravity through the engine cylinder jackets and back to the cistern where it is again picked up by the pumps.

Water is pumped from the spray pond through the

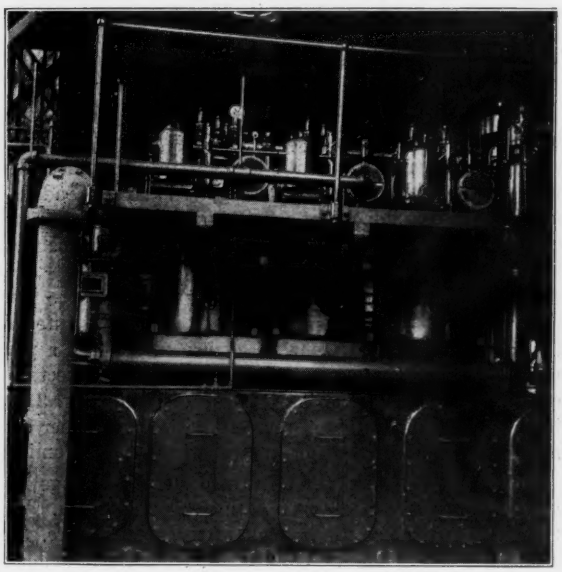


FIG. 2. WORTHINGTON THREE CYLINDER AIR INJECTION DIESEL ENGINE. EXHAUST PIPE IS SHOWN IN FOREGROUND TO LEFT

heat exchanger and returns to the pond through the spray nozzles. This water is at present handled by a 5-in. American Well Works single stage, centrifugal pump, which is direct connected to a 220-v., 855-r.p.m., induction motor. In all probability, another pump for this unit will be installed in the near future.

Another interesting feature may be found in that the old surface condenser which served the steam engine, is so piped up that it can be used as a heat exchanger for the operation of the Diesel units, while the regular heat exchanger is being cleaned or is otherwise out of service.

Forced feed lubrication to the engine cylinders is accomplished by means of Manze Bros. Co. forced feed lubricators. Bearing lubrication is obtained by means of a pump mounted on the engine shaft. Oil is pumped from a sump tank through a strainer and then to the bearings from which it drains back into the sump tank. An S. F. Bowser & Co. batch filter has been installed. About once every three weeks the oil from each engine is cleansed by means of this filter.

In order to heat the oil in the Bowser filter and also to heat the fuel oil in the overhead tanks, a jacket has been welded around the exhaust pipe of one of the Diesels. By throttling down on the amount of water passing through this jacket, its temperature can be raised, so that it can be circulated through the coils in either the lubrication oil filter or the fuel oil tanks. It will not be necessary to heat the fuel oil except in cold weather.

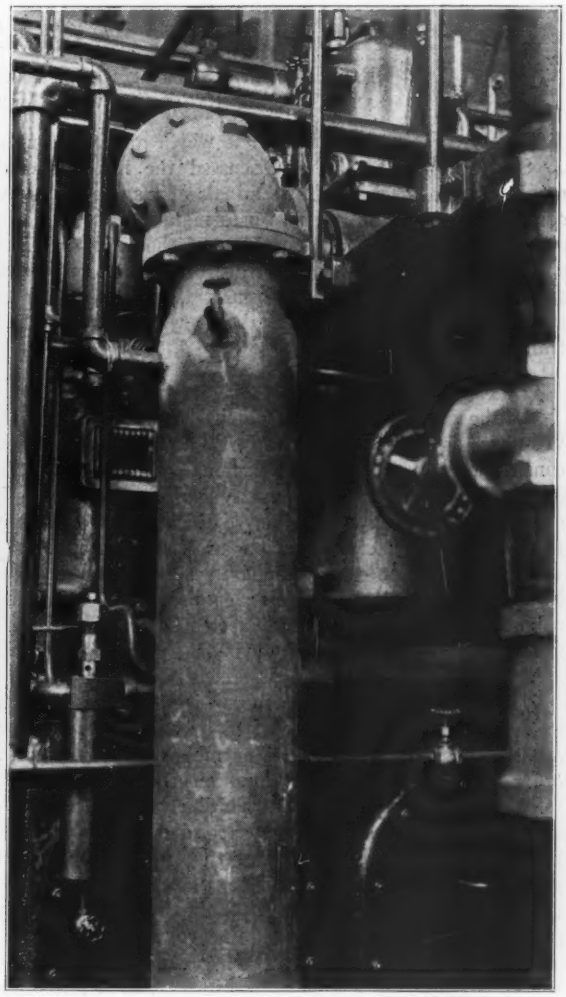
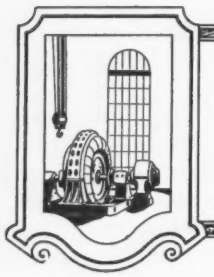


FIG. 3. WATER JACKET WELDED AROUND EXHAUST PIPE FOR HEATING FUEL AND LUBRICATING OIL

Air for starting can be obtained either from storage cylinders or from a Clayton two-stage compressor, which is belt driven by a small kerosene engine. In changing over this plant from steam to Diesel operation, it was necessary to add two new panels to the switchboard. The space occupied by the new units was formerly a pump room, the partition wall between it and the engine room having been removed and the roof raised over the new engines.

THE MORE evenly the water is passed through a feed water treating system the more complete will be the treatment.



ELECTRICAL MACHINERY FOR LIGHT AND POWER

Principles of Transformer Connections

PART II. PRINCIPLES OF PHASE TRANSFORMATION. A DISCUSSION OF VOLTAGE AND CURRENT RELATIONS WITH VARIOUS CONNECTIONS. BY V. E. JOHNSON

IN THE first part of the article which appeared in the September 15 issue, we discussed the methods commonly used in marking the terminals of transformers. As stated in that article when transformers operate alone on single phase systems, the marking of the leads is of no consequence but when several transformers are to operate together, it is important to connect the proper leads together. In this article we will take up systems of polyphase transformation.

TWO-PHASE TRANSFORMATION

Of the various systems of polyphase transformation, the two-phase is perhaps the simplest. A two phase system consists of two single-phase systems whose voltages are displace 90 deg., or as commonly expressed they are in quadrature. Such a system may consist of three wires or four wires. The voltage relations are shown in Fig. 1.

Transformation on a two-phase system is accomplished by means of single-phase units, connected in each phase as shown in Fig. 2 or interconnected as in Fig. 3. It is also possible to have four-wire primaries feeding three-wire secondaries as in Fig. 4.

It will be noted that on a three-wire, two-phase system, an accidental ground on one of the outside wires will put a potential stress of 1.41 times normal voltage between the other wire and the ground. Thus on a 2300-v. line there might be a stress of 3243 v. Similarly on a three-wire, two-phase, 115-v. secondary, a ground on one side would produce a potential to ground on the other, of 162 v. By grounding the common point on the secondaries of the transformers as shown in Fig. 4, the possible voltage to ground can not exceed normal line voltage.

It is also possible to interconnect the middle points of the generator windings as shown in Fig. 5. Under these conditions, and with the point of interconnection grounded, the potential stress is reduced to one-half normal line voltage. Transformers may also be interconnected in a similar manner, with similar results. See Fig. 6. The connection shown in this figure is of course also obtained by grounding the middle point of both units. The arrangement of the windings in the connected apparatus determines largely what scheme shall be employed.

THREE PHASE TRANSFORMATION

A three-phase system consists essentially of three single-phase systems, operating with a 120 deg. phase displacement, inter-connected in various ways, and using either three or four wires for the transmission of power. Transformation is accomplished by means of single phase or three phase units connected in a great variety of ways.

Figure 7 shows the general connections and voltage relations of a three-phase system, using a common return or neutral wire. Except for special cases, to be noted later, the neutral wire may be omitted, leaving a three-wire, three-phase system as shown in Fig. 8.

THREE PHASE TRANSFORMATION USING SINGLE-PHASE UNITS

From Fig. 7 it will be seen that on a three-phase system loads may be carried between the phase wires, or between these and the neutral. With the neutral disconnected, it would be possible to carry three exactly balanced loads connected to a common point as shown, but the slightest inequality in the current flow, would produce unbalanced voltages, except under rather special conditions.

Figure 9 closely resembles Fig. 7, the difference being that three transformer windings have been substituted for the loads. Each transformer is connected between a phase wire and a common or neutral point. Such a connection is called "star" or "Y". Figure 10 differs from Fig. 8 only in that the loads have been replaced with transformer coils, as in Fig. 9. The fourth or neutral wire has been omitted.

Figure 11 shows three transformers windings connected across the phases of a three-phase system. With this arrangement no use is made of the neutral wire. This scheme is called "delta" connection, from its resemblance to that Greek letter.

CURRENT AND VOLTAGE RELATIONS WITH STAR CONNECTED WINDINGS

With a connection such as that in Fig. 10, the line current passes directly into the transformer, so that the latter must carry the entire ampere load. This is indicated by the values marked on the sketch. This may be expressed thus:

"In a star connected transformer setting, each transformer must carry the entire load current, that is:

Transformer Current equals Load Current."

The voltage from neutral to line is the same as the voltage across any transformer winding, but the voltage from phase to phase is 1.73 times this value. This is shown graphically in Fig. 12, where Ea, Eb, and Ec are the transformer potentials and El the line potential.

The increased voltage rating obtained by the star connection is a desirable feature which leads to its common use on a great variety of applications. For example, three standard 2300-v. primary transformers may be star connected to a 4000-v. (to be exact 3979-v.) line. Similarly 66,000 v. is often obtained by star connecting three 38,100-v. units.

Current and Voltage Relations with Delta Connected Windings

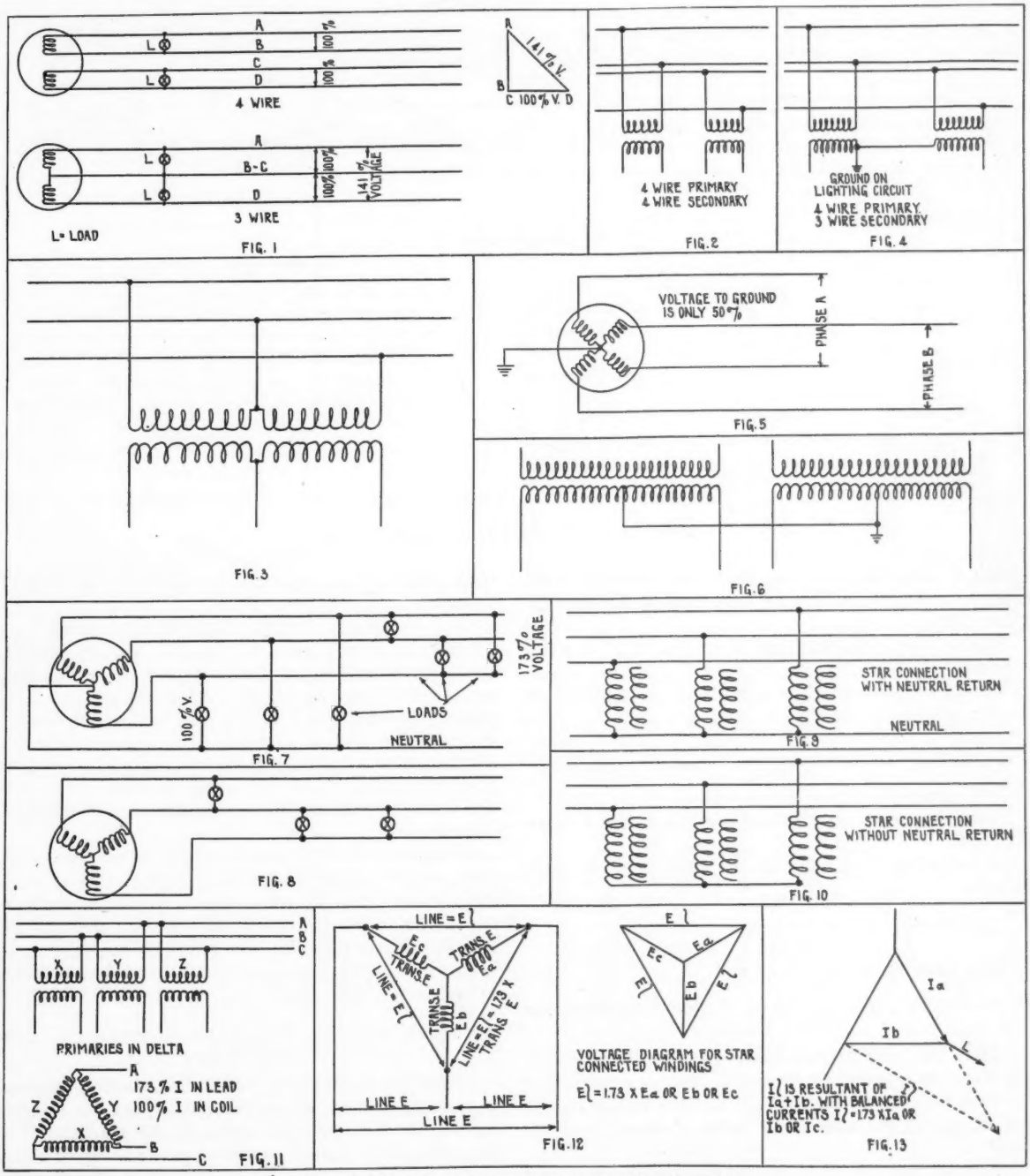
With a connection such as that shown in Fig. 11, the load current divides into two paths as it enters the transformer bank. Consequently either winding carries less than the full ampere load, and conversely the latter is greater than that in any one of the legs. Mathematically this relation is as follows:

With balanced loads, load current equals 1.73 times that in any transformer winding. This is indicated by the values marked on the sketch.

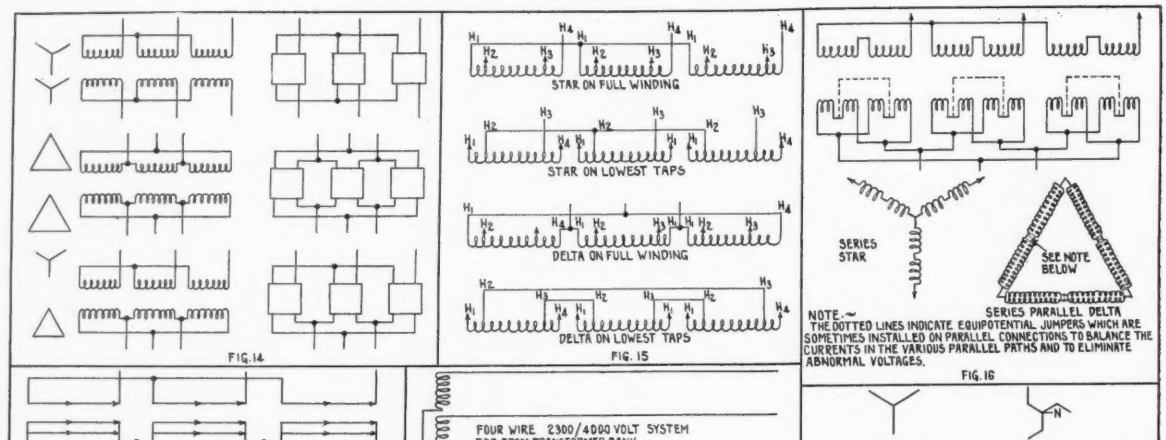
Figure 13 shows graphically the method of arriving at the above relations. Ia and Ib represents the current in two phases feeding into the line L, and giving the resultant value Il.

Combined Ratings of Three Transformers Connected Star or Delta

In either of the above cases the rating of the bank equals the sum of the individual ratings, assuming that the units are identical. Or, if each unit has a capacity of N kv.a., the bank will be 3N kv.a. This checks with the formula for the total kv.a. expressed in terms of line current and voltage, viz: kv.a. equals $EI \times 1.73 \div 1000$, where E equals voltage from phase to phase, and I the current in the line wire.



FIGS. 1-13. TWO AND THREE-PHASE CONNECTIONS


STAR ON FULL WINDING
STAR ON LOWEST TAPS
DELTA ON FULL WINDING
DELTA ON LOWEST TAPS
SERIES STAR
SEE NOTE BELOW
SERIES PARALLEL DELTA
NOTE.— THE DOTTED LINES INDICATE EQUIPOTENTIAL JUMPERS WHICH ARE SOMETIMES INSTALLED ON PARALLEL CONNECTIONS TO BALANCE THE CURRENTS IN THE VARIOUS PARALLEL PATHS AND TO ELIMINATE ABNORMAL VOLTAGES.
FIG. 14
FIG. 15
FIG. 16
FIG. 17
FOUR WIRE 2300/4000 VOLT SYSTEM FED FROM TRANSFORMER BANK
NEUTRAL
FIG. 19
FIG. 21
2300 VOLTS FROM LINE TO NEUTRAL
4000 VOLTS FROM LINE TO LINE
GENERATOR Y CONNECTED
NEUTRAL
FIG. 18
3 ϕ LOAD
1 ϕ LOAD
FIG. 20
FIG. 22

FIGS. 14-22. THREE-PHASE CONNECTIONS

Let V and C be respectively the voltage across, and the current in a given unit. Its kv.a. rating will then be $VC \div 1000$.

For star connected windings E equals $1.73 \times V$, and I equals C.

Substituting these values in the formula for the bank rating:

$$\text{Kv.a.} = \frac{(1.73 \times V) \times C \times 1.73}{1000} = \frac{3 \times VC}{1000}$$

or three times the rating of one unit.

For delta connected windings E equals V and I equals $1.73 \times C$.

Substituting these values in the formula for the bank rating:

$$\text{Kv.a.} = \frac{V \times (1.73 \times C) \times 1.73}{1000} = \frac{3 \times VC}{1000}$$

or three times the rating of one unit.

Ratio of Transformation of Banks Consisting of Three Units

From the foregoing discussion of the effect of connecting transformer windings in star or delta, it appears that the ratio between the high voltage and low voltage lines is not necessarily the same as the ratio of the units in the bank.

Assume that the turn ratio of the transformers in a given bank is 1000/100. Then the bank ratio will be as follows:

With delta high and delta low the ratio will be 1000/100 or 10/1

With star high and star low the ratio will be 1730/173 or 10/1

With star high and delta low the ratio will be 1730/100 or 17.3/1

With delta high and star low the ratio will be 1000/173 or 5.8/1

Any of the above combinations, with the exception of the star-star arrangement may be used without difficulty, and a considerable range of voltages obtained with a given rating. The star-star can be used if the neutral of the primary be connected to the neutral of the generator, or if some other means be adopted to maintain balanced voltages under unbalanced loads. In conjunction with the series parallel and tapped windings discussed in the previous article, it is possible to secure a great variety of connections.

Example: A central station wishes to use three 4600/2300 to 230-v. transformers on a 4000-v. line to obtain 230 v. three phase. By connecting each unit in parallel on the high side the individual ratio becomes 2300 to 230. By using a star high side and delta low side scheme, the ratio will be 3979/230 which will be entirely satisfactory to use on the 4000-v. line.

Actual Method of Making Connections on Three Unit Banks

Figure 14 shows vector relations, connection diagrams, and actual methods of making connections for star-star, delta-delta, and star-delta banks. If the individual units have their leads marked according to the Rules, or if they are all marked in the same manner, even though not in accordance with the Rules, any of the shown combinations are easily made. In the case of the star connection, three similarly marked terminals are joined, and the other three tapped to the line. Thus if the unit had two taps brought out so that the leads were marked H1, H2, H3, and H4—H1 and H4 being the full winding terminals, the Y could be made by joining the H1 leads, and bringing the H4 leads to the mains. If the lowest taps were to be used, the

H2 should be joined and the H3 leads brought to the mains.

For the delta connection, the lowest numbered lead on each transformer is joined to the highest numbered lead on the next, and this common point brought to the line. Thus for the units having taps as indicated above, the full winding delta would be formed by connecting H1 to H4 and this common point to the line. If the lowest taps were to be used, H3 on one winding would go to H2 on the next, and this common point to the line as before.

The diagram in Fig. 15 will serve to make the two preceding paragraphs clearer. If dissimilar transformers are to be connected in delta or star, the taps giving equal voltages on the three units should be used, although it is possible to operate quite satisfactorily with some little difference between them.

If multi-coil transformers arranged for series parallel operation are to be used, with their coils multipled, the problem is essentially the same. Each unit must be reduced, so to speak, to its lowest terms, with its two final terminals selected for use in the bank. This is easily understood by referring to Fig. 16, where the three units are shown both actually and schematically connected.

In making a diagram such as that in Fig. 16 it simplifies matters somewhat if arrows are used to indicate the relative polarities of the individual coils. Figure 17 shows this plan applied to the scheme in Fig. 16 and also indicates how these arrows may be used for forming the star or the delta.

Three Phase Four Wire 2300-4000 v. System

Brief reference has already been made to the three-phase, four-wire system, but its extended use warrants giving it further consideration. The advantages to be obtained by its use are those of lower line losses due to a higher transmission voltage, plus the fact that this is obtained by using standard 2300-v. apparatus.

On a feeder going out directly from the power house, the neutral is obtained from the Y point of the generator. If, on the other hand, the distribution feeder comes from a sub-station, the fourth wire is connected to the neutral of the main transformers. These two methods are shown in Figs. 18 and 19.

Figure 20 shows a typical four-wire feeder supplying single, and three-phase loads. The former are tapped between the neutral and one of the phase wires, care being taken that a fairly even division of load is maintained. On these two-wire taps, 2300-v. transformers are used, the secondary being connected to the secondary loads, as indicated in the sketch.

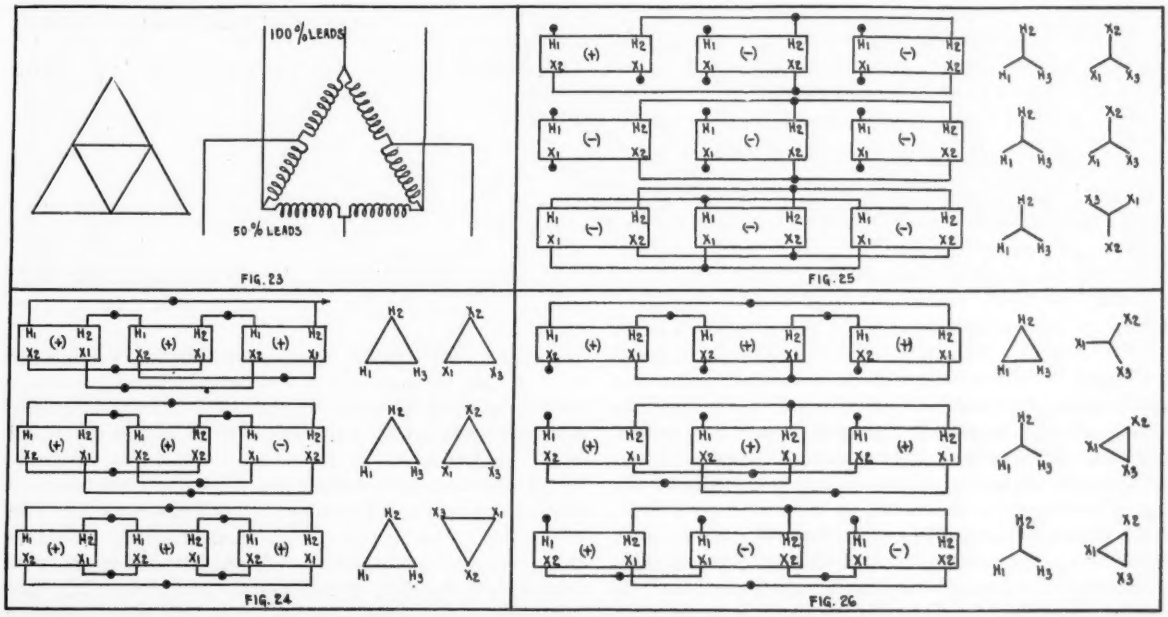
The three-phase loads are supplied by three units connected star on the high side and delta on the low, the neutral being left unconnected. If the neutral were connected, a circulating current might be set up in the closed delta, which might cause undesirable heating. There is also some tendency for the feeder to try to balance out any inequalities in voltage through a bank so connected, and this would add to the burden on the windings.

With standard units there will seldom be any need of a star-star connection on a 4000-v. system, as this would give a seldom used secondary voltage; however, if used, the primary neutral must be connected in order to maintain balanced voltages.

Interconnected Star or Zigzag Connection

This method of connecting three transformers on three-phase systems is little used in this country, except for rather special purposes. Standard units may be used, but the side to be zigzag connected must have a two section winding. Figure 21 shows the connection diagram for star to zigzag, while Fig. 22 shows the arrangement for delta to zigzag. The vector diagrams show the resulting voltage relations.

The zigzag scheme permits a star-star connection without any unbalancing of voltages with the primary neutral disconnected. It has no particular advantages over the star delta arrangement from the standpoint of operation, and has the disadvantage of being complicated and confusing. Furthermore for the same rating, 15 per cent more copper is required in the zigzag windings, and the effi-



FIGS. 23-26. THREE-PHASE CONNECTIONS

ciency is somewhat reduced, as compared to a straight star-star setting.

The zigzag connection has a logical application in providing a direct current neutral point for rotary converters supplying three wire Edison systems, in cases where heating would result from the increased core loss caused by the magnetic effect of the neutral current in a straight Y connection.

Double Voltage Secondaries in Delta Connection

On transformers having two coil secondaries, a connection such as that shown in Fig. 23 may be used to supply three-phase loads at two different voltages as indicated. With this arrangement it is possible to feed combined loads smaller than the rating of the bank. For example, a 10-kv.a. setting could supply 5.5 kv.a. on the full voltage leads, and 3 kv.a. on the 50 per cent leads or a total of 8.5 kv.a., if the power-factor were near unity. Lower power factors would still further decrease the simultaneous rating.

Typical Connections

Figure 24 shows a number of possible conections for delta-delta banks made up of units having both additive and subtractive polarity, as indicated by the (+) and (—) markings. The vector diagrams indicate the resulting voltage relations. Figure 25 represents a variety of possible star-star combinations for different polarities, with voltage diagrams indicating the phase relations.

In Fig. 26 are shown a number of different star-delta connections with voltage diagrams.

In the foregoing figures, the voltage diagrams are almost indispensable in predetermining the possibilities of parallel operation. This subject will be dealt with fully in another article.

Skyscraper Substation

AN INTERESTING modification of substation construction, adapted to local circumstances for the purpose of securing necessary floor space on a restricted ground area, is made at the Pittsburgh Plate Glass Co. plant at Creighton, Pa. This plant was newly built about 2 yr. ago and, for the past several months, plans have been under way for doubling its capacity.

In common with most industrial plants in the vicinity of Pittsburgh, the Pittsburgh Plate Glass plant is confined to a rather narrow section of land between mountains and river, the only level ground being along the banks of either the Monongahela or Allegheny rivers. The natural topography of the land thus allowed a maximum width for the substation in question of but 20 ft., with no restriction, however, on the height of the building.

Acting, therefore, on principles of land conservation practices in large and crowded cities, the Pittsburgh Plate Glass Co. designed the substation for its Creighton plant for a height of four stories. This type of construction was adopted when the plant was first built, 2 yr. ago, the company officials foreseeing, at that time, the present expansion. Outdoor switching equipment was also designed, at the beginning, for the ultimate capacity of the plant.

All the electrical equipment in the substation and a considerable part in the plant is of General Electric manufacture, the plant being completely electrified. Power is purchased from the West Penn Power Co., Pittsburgh, Pa., is received from two 25,000-v., three-phase, 60-cycle transmission lines, and is stepped down by transformers to 550 v.

Inside the substation were originally installed two 300-kilowatt motor generators for supplying direct current to cranes and auxiliary motors, one low tension switchboard for operating the motor generators and for controlling feeder circuits, and a 3000-kv.a. synchronous condenser for improving the power factor on the induction motor load. In doubling the plant capacity, the present motor generators will be replaced by 600-kw. sets, and a second synchronous condenser of the same rating will be installed together with duplicate transformer equipment.

Semi-Automatic Operation for Small Hydro Plants

Installation of Automatic Equipment to Convert Manually-Operated Plants Into Semi-Automatic Plants Proves Successful. By C. W. Geiger

BECAUSE OF the many advantages of the automatic and semi-automatic small hydro-electric plant over the manually operated type, the Pacific Gas and Electric Co. has changed a number of its manually operated stations over to the semi-automatic type. The elimination of the cost of manual operation is an important factor in favor of the automatic station and especially in the care of new installations makes possible a much different treatment of many hydraulic developments.

At the Hat Creek plants, No. 1 and 2, on the P. G. & E. system, it has been possible to install automatic control equipment to the extent that one man can now operate each station. To do this it was necessary to make the following changes:

1. Move the control switches for the governor oil pump, governor air pump, and butterfly valve motors to the generator floor near the switchboard for the convenience of the operator.

2. Make the governor oil system automatic in operation by connecting the oil pressure line to an unloading valve through a float arrangement in the oil pump, and installing diaphragm pressure switches with alarm on the governor pressure tank.

3. Installation of positive acting mercury alarm switches in the cooling water systems.

4. Provision of a governor on the exciter circuit.

5. Installation of a tachometer for the exciter, on the switchboard.

6. Installation of a solenoid trip on the turbine governor, which causes the governor to close the turbine gates when trips operate.

7. Installation of overload relays on generator leads and relays provided for protection against internal generator trouble.

At the Coal Canyon plant located about 10 mi. from Orville, Cal., equipment has also been installed to change it from manual to semi-automatic operation. It is now operated by one man who resides close to the plant and who is subject to call at any time.

In case of trouble at this plant an alarm bell rings in the power house and in the operator's house notifying him of trouble. The operator then immediately proceeds to bring the machine back to speed, synchronizes it and puts it back onto the line. The power plant is arranged to take all water continuously. As the amount of water entering the forebay increases or decreases the needle automatically

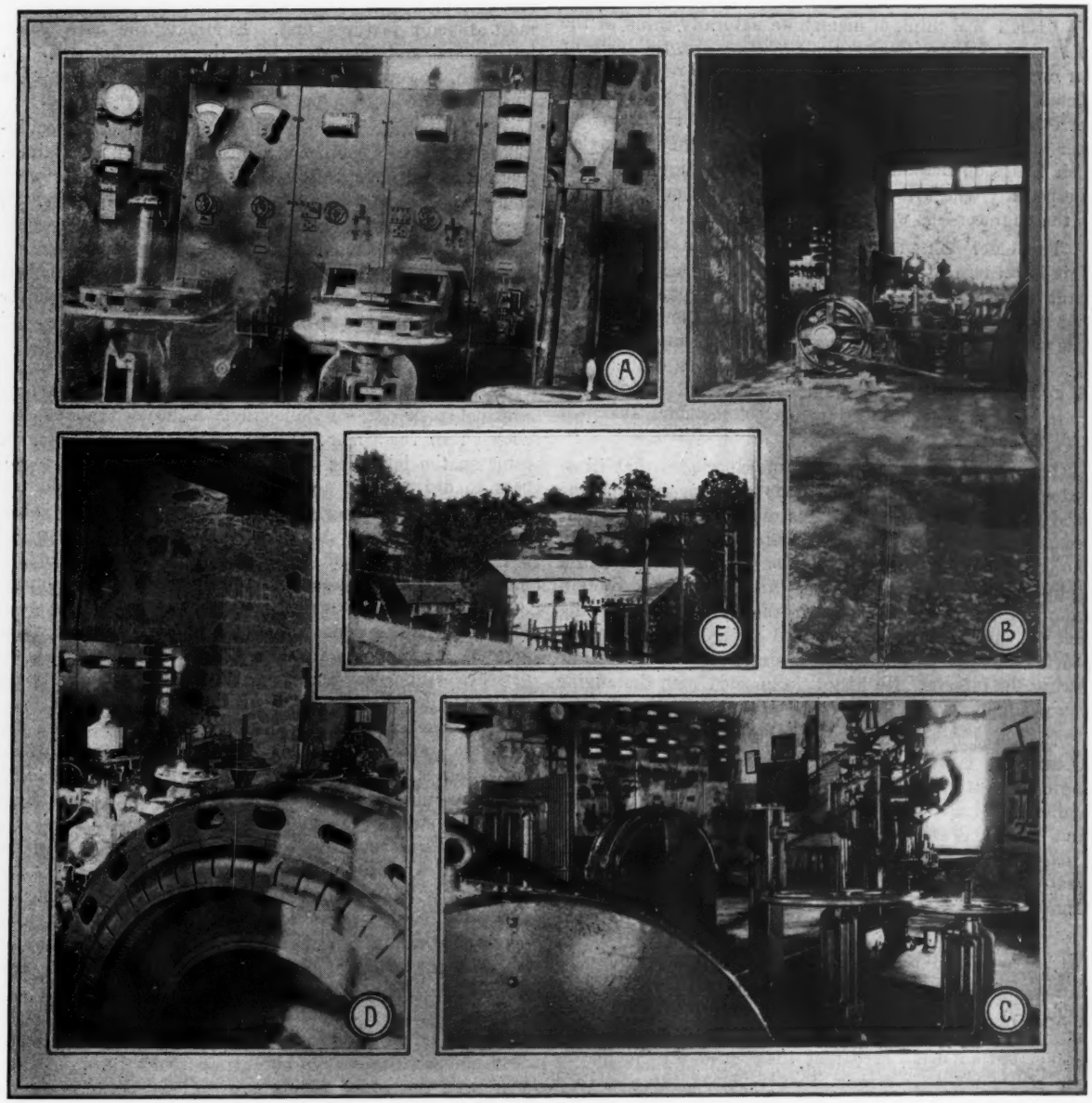
opens or closes to maintain a constant level in the forebay. There is no governor on the machine. Water after passing through the plant is used in the domestic water supply by the City of Orville, thus it is always necessary to keep the water passing through the plant. In case of a shut down of the plant a deflector of the company's own design takes the jet off the water wheel, and the water continues down the tail race.

Coal Canyon plant is equipped with a 1400-hp. Pelton impulse water wheel operating at 2300-v. and feeds into a 60,000-v. transmission system.

The Cow Creek plant and Deer Creek plant are also being changed to semi-automatic operation, and it is contemplated to change a number of others. Cow Creek plant is equipped with two Pelton single overhung water wheels of 1500-hp. capacity. This plant is located northeast of Red Bluff.

Deer Creek plant has installed a 7500-hp. double overhung Pelton water wheel. Each of the latter two plants is now operated by three operators working on an 8-hr. shift. One operator is employed who acts as relief for each man one day each week.

At some of the small power plants located so far from human habitation that it requires a half day to reach them during good weather and where it is impossible to reach them during the winter two men will be stationed even though it is only necessary so far as operation of the plant is concerned to have one man. For example, at the Deer Creek power plant one man will handle the water ditch in addition to assisting the operator of the plant.



VIEWS OF SMALL HYDROELECTRIC PLANTS OF THE P. G. & E. CO.

A. Switchboard at Cow Creek before rebuilding. B. Interior view at Cow Creek showing exciter at left. C. An interior view of the Coal Canyon station. D. Another view at Cow Creek. E. Cow Creek station.

Plant History Assists in Upkeep of Equipment

LACK OF ADEQUATE REPAIR RECORDS FREQUENTLY CAUSES EXPENSIVE DELAYS. BY C. C. HERMANN

WHEN WE think of history we naturally think of the time of Nero, Caesar, the Christian era, the birth of our own country and many other things but remotely connected in our minds. Rarely do we think of power plant performance as history; yet history it is and many engineers have at some time or other wished they could lay their hands on the history of some particular plant. This is especially true with a plant old in performance but new to the engineer—as when changing plants.

The older the plant the more valuable the history. This is because so many things can take place in the old plant that baffle the new engineer. Equipment in the first place old and in the second place somewhat out of date often calls forth the maximum of ingenuity on the part of the engineer. Because the plant is old and its past history unknown, the engineer is placed on his most irritable pegs in attempting to forecast the thing that will happen next.

I recall an instance in my own experience that illustrates the point. I had the misfortune, or perhaps the good fortune, to change positions numerous times without becoming what is known as a chronic job hunter. On one occasion, among other equipment of antiquity I had a 50-hp. simple engine. All the history I could obtain regarding the engine consisted in the book record showing that the engine had been purchased secondhand some years previous and that it had been operated only a short time during the interval. No history connected with the engine was available.

I ordered the engine overhauled and placed in shape to drive an air compressor. Steam was turned into the engine and it responded in fair shape at first but at the higher speed a decided click developed. The engine was shut down and everything gone over a second time without disclosing anything that might cause the knock. The engine was again started and the click plainly heard at the same point in the speed.

At that instant, an old pattern maker came into the engine room and remarked that as he recalled the same trouble had been experienced years ago and they had been unable to detect the trouble. The machinist worked on the engine another half day without finding anything wrong, but to make sure that their guess in the matter was either right or wrong, they replaced the crosshead pin. The click was still with the engine. The master mechanic came to me and reported the matter, stating that they were unable to locate the trouble. I went out with the master mechanic but was no closer to the real seat of difficulty than he and I frankly admitted this fact.

I had a friend who has been a stationary engineer in another plant with which I had been connected and thinking that perhaps he could throw some light on the matter, I called him over. After listening to the engine for a few minutes and questioning the boys regarding the work done on the engine he asked them if they had removed the head. The answer was no. Well, everybody tumbled at the same instant and the head was removed. A three-quarter turn on the piston head nut cured the trouble.

Why, you may ask, was so much time wasted in locating such a simple trouble? The answer is suspicion. Everybody was suspicious of the engine. Standing so long seemed to spell all kinds of difficulty and when the click was heard of course everyone started looking for the trouble in some complex corner of the mechanism. It seems to be human nature to look over and investigate the most difficult features first. Eliminate the hard possibilities first and then start after the minor elements. In this case, however, the crew stopped before the minor or simplest sources of such a click had been investigated.

This illustrates that regardless of the size of the equipment some record of performance should be maintained. Such a record only requires a few minutes a day or week and will save hours and hours at some time or other. If the log for this same engine were examined today it would disclose every repair, including a brief account of the click, from that day to the day the writer left the plant at least and, from the caliber of the man following me, I believe I am safe in saying, up to date.

FEED PUMP NEEDED RE-BORING

A friend was relating some of his troubles to me among which I pick out the following. A decided pound was detected in the boiler feed pump the first day after he came on the job. The old engineer was in a hurry to depart so did not get around with him as he should but elicited just some meager information regarding the valves before he got away. A pound in a boiler feed pump did not seem complicated. Probably an obstruction in the water supply line resulting in a reduction of water supply to the pump, yet enough to keep the boilers going in good shape; perhaps a loose water piston or leaky foot valve or some other simple trouble. He had some valuable experience with power plants, so he reasoned that he would have little or no difficulty in locating the trouble.

He looked about for an auxiliary pump but there was none, so he decided among other things that he would have another pump at the earliest opportunity. The trouble, however, must be located before that, so that same night after the steam pressure in the boilers was down to a point where he could feed city water direct he stopped the pump and went after the trouble.

The trouble was not located that night. He completely exhausted every avenue of investigation he could think of without result. The next day found the pump back on the line but still pounding. The next day, however, was close to the middle of the month and his copy of a power plant magazine came to hand. He grabbed this up quickly and searched its pages for some enlightenment on his boiler feed pump. Sure enough here it was. "At times the water piston of the boiler feed pump will fit tighter at some part of the stroke than at another point, due to unequal cylinder wear, in which case a decided pound will be audible." Enough said. He obtained the necessary instruments during the day and that night he investigated the water cylinder. Here it was just as his favorite magazine had pointed it out to him. The cure lay in re-boring the cylinder and because the pump must be laid up for the time being a new pump was forthcoming without delay. He now has two almost new pumps in his boiler room.

I stated that a history or log of the power plant equipment is a good thing and repays with dividends the cost expended in its keeping. I shall qualify this by stating that it depends somewhat upon the system followed. The simpler the better, since there are many things about the

power plant that must receive the attention of the engineer so that practically every minute of the day is taken up with some form of activity.

All that is necessary is some repair order system that admits placing the information direct on the order. Such information as machine number, date, nature of repair, cost of repair, and new parts used is about all the information except, perhaps, a line or two for personal notes, relative to the repair, to be filled out by the engineer. Once a week or oftener one of the office clerks can copy this information into a book kept for the purpose. Cards serve as an efficient way to keep the information but there is one objection and that is that over a period of years one or more of the cards may become misplaced and the record broken. A new man coming on the job can look over this record and get started away on both legs.

Welding Aids Builders of Ammonia Equipment

USE OF ELECTRIC WELDING ENABLES MANUFACTURER TO FURNISH TIGHTER AND STRONGER APPARATUS AND SIMPLIFIES MANUFACTURING PROCESSES. BY L. H. BURKHART*

ELECTRIC WELDING is coming into more common use at the present time in the construction of vessels and equipment for handling ammonia. Welded construction allows joints to be made tight against leakage of ammonia vapor and has the further advantage of lending itself admirably to the construction of ammonia equipment from steel plate, which produces a stronger and safer vessel than can be produced with other materials. A few comments on the general processes of welding ammonia equipment are given here, together with a detailed description of the method of building a shell and tube type ammonia condenser, using the electric welding process throughout.

One of the most important and interesting uses of welding is in the construction of multi-pass horizontal ammonia condensers and brine coolers. The construction of these is similar to that of the vertical shell and tube type ammonia condenser with steel plate tube sheets welded directly to the shell and with the addition of water or brine heads bolted on the outside against each tube sheet. These heads are equipped with baffles to create the several passes of the water or brine through the tubes and with steel baffle plates at intervals across the tube space to deflect the ammonia vapor across and around the tubes several times in its passage from inlet to outlet. The welding in the construction of this vessel consists of welding the longitudinal seam of the shell and the tube sheets to the shell, as will be described in detail below.

Ammonia receivers, which are cylindrical tanks up to about 30 in. in diameter, can also be made by welding. These receivers are made of steel plate with dished heads at each end welded to the shell, all seams of the shell and head being welded inside and outside by the electric arc process. These ammonia receivers are usually tested to 500 lb. hydro-static pressure, which is twice the maximum working pressure. They would, however, hold more pressure than that applied during the test.

Oil traps and pipe headers are successfully and economically made of extra strong steel pipe electrically welded into the forms required. This apparatus is usually tested to twice the working pressure or 500 lb. hydrostatic pressure.

Ammonia accumulators are often welded. These are cylindrical tanks of steel plate with dished bottoms, all seams electrically welded. A cover of cast steel is bolted to an angle ring around the top of the shell. The cover carries a series of stuffing-boxes for the inlet and outlet pipes for the coils with which the tank is equipped. These vessels are usually tested to 300 lb. hydrostatic pressure.

It may be of interest to refrigerating engineers to give some details of the method used in the construction of a shell and tube type ammonia condenser, such as that shown in Fig. 1. This operation was described in a paper read by the author at the meeting of the A. S. R. E. in Milwaukee in May, 1925.

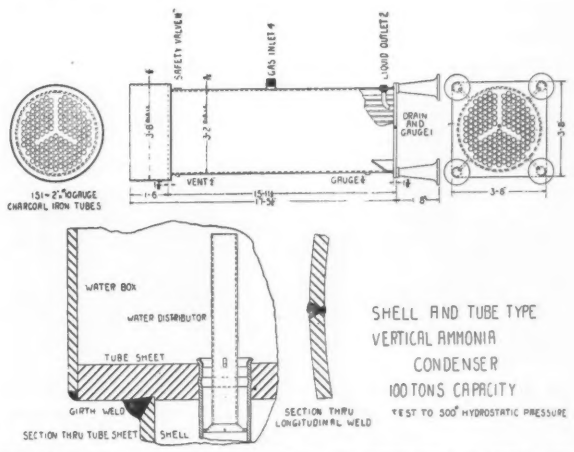


FIG. 1. SECTIONS SHOW METHOD OF BEVELING PLATES AND WELDING SEAMS ON SHELL AND TUBE TYPE AMMONIA CONDENSER

In assembling the condenser shell, three seams are electrically welded; the longitudinal seam and two girth seams. The shell is 9/16-in. steel plate, the other dimensions being as shown in Fig. 1. Reference to this drawing shows details of the seams.

The plate for the shell is planed along its edges to exact size and beveled to form a 60 deg. "V" joint for electric welding. The sides which will form the ends of the cylinder when rolled up are beveled back so as to form an angle with the tube sheets of about 60 deg. The tube sheets are turned and planed around their outer edges to size and a chine is turned into each for the reception of the ends of the shell and to afford a clean metal surface for welding. The tube sheets are laid out for the correct number of tube holes and their centers prick punched.

A ¾-in. pilot hole for each tube hole is drilled through the heads assembled in pairs. This is found advisable, due to the fact that a 2 1/32-in. drill does not drill a true, smooth hole when used without the pilot hole.

After the 2 1/32-in. holes have been drilled, a special tool for counterboring is used to ream out the groove at the center of the sheet in each tube hole. Figures 1 and 2 show the groove in detail.

All openings having been located and punched or drilled in the shell plate, it is now rolled to a true cylinder and clamped securely in that position. The long seam of

*Chief Engineer, Struthers-Wells Co.

the shell is now adjusted so that at one end the two edges of the plate are about 1/16 in. apart and at the opposite end the seam is open an amount equal to about 1/16 in. per foot of length or about 1 in. for the case in hand. This arrangement of the seam for welding is not absolutely necessary, since the edges may be brought parallel to each other and then tacked in this position and welded. A seam welded with the first scheme of assembly, however, is freer from locked up stresses than it would be by using the latter scheme.

The long seam is welded by running one string of welding the full length outside. Then if the plate is ½ in. and thicker, a second string is placed over the first string of welding. The imperfectly united edges of the shell plate on the inside are now chipped out with a diamond pointed tool and a third string of welding run on the inside, each side being built up about 10 per cent. A weld thus made will not leak under pressure, for there are no pin holes completely through the seam and the welded seam will be stronger than the plate.

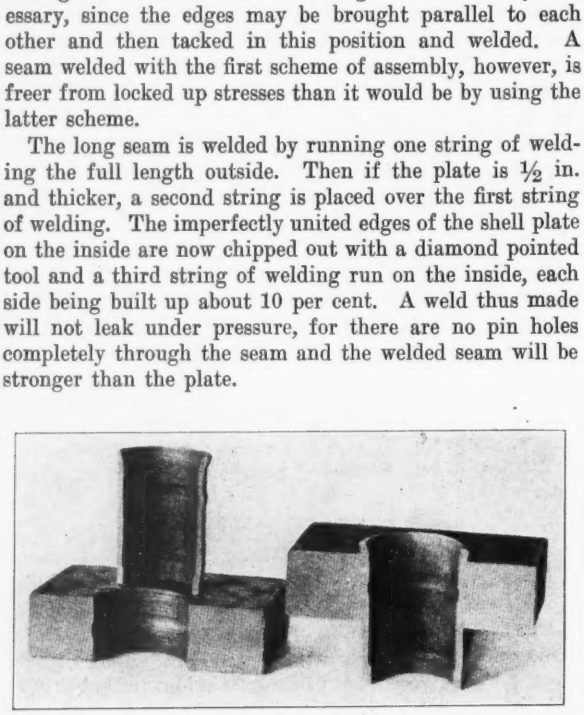


FIG. 2. SECTION THROUGH TUBE AND TUBE SHEET SHOWS TUBE BEFORE AND AFTER ROLLING. SPECIAL EXPANDER ROLLS TUBE INTO CHINE

All openings, such as nipples, couplings and pipe bushings, that require welding from both sides are now inserted and welded into place. The tube sheets are then assembled at the ends of the shell and drawn into the chines by through bolts and nuts operating through the tube holes of the tube sheets. When this assembly is completed, the through bolts are allowed to remain in place while the welding of the shell to the tube sheet is being done. This is done by using two or three strings of welding. There is a tendency of the girth welds to dish the tube sheets out at their centers. This strain is counteracted by the through bolts which remain in place until all the welding of the girth seams is done.

The tubes are now inserted and rolled tight with a power driven expander and the flare at the end rolled on. A second rolling operation, with a special beaded roll, is done to roll the tube into the recess of the tube hole.

Testing the Finished Condenser

The condenser is now ready for test. This is done by filling the space around the tubes with water and a pressure of 500 lb. per sq. in. pumped up.

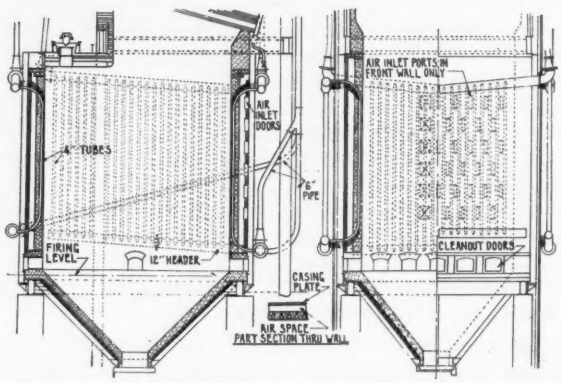
Some engineers specify an air test under water. Such a test for a condenser is not practical, for while the leaks may be located, it is difficult to mark them and they cannot be repaired under water, so the condenser has to be removed from its bath. If the leaks could be marked properly, and stopped, then a reimmersion of the condenser would have to be made, all of which means disconnecting pipes, the use of a crane and a lot of time wasted before the condenser is tight. Such a process of testing is anything but satisfactory.

After the test is completed, the water box shell is welded in place, the condenser cleaned and openings plugged, shell painted outside, after which it is ready for shipment.

In constructing electrically welded vessels, the only objection which we have encountered is that the insurance companies have not yet accumulated sufficient data to warrant them in accepting these vessels for insurance. A code for electric welding is in process of preparation and this code, when adopted will, without doubt, be recognized by the insurance companies to the extent that it will give them the supervision of welding in any plant; with this supervision, they will then be in a position to accept the construction for insurance.

American Pulverized Fuel Equipment Used in Europe

NEGOTIATIONS HAVE recently been completed between the Fuller-Lehigh Co., through their European representatives, Messrs. Babcock & Wilcox, Limited, and the Societe d'Electricite de Paris for a pulverized fuel installation at the St. Denis Station which will be by far the largest installation of this kind yet made in Europe.



FURNACE ARRANGEMENT TO BE USED IN THE PULVERIZED FUEL INSTALLATION AT THE ST. DENIS STATION

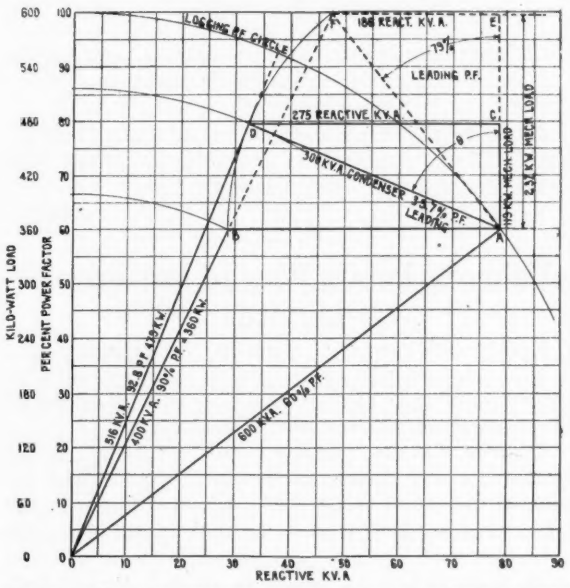
The St. Denis station is located just outside of the Paris city limits on the River Seine.

Boiler equipment consists of 8 B. & W. boilers each of 1000 sq. meters (10,760 sq. ft.) of heating surface, producing 55 T., maximum, of steam per hour each at 315 lb. pressure and 375 deg. C. (707 deg. F.) total temperature. The coal used will vary somewhat as to quality, but will have an average heating value of 6000 calories (10,800 B.t.u. per lb.), with about 12 per cent volatile, 20 to 22 per cent ash and 5 to 10 per cent moisture, with ash fusion temperature of 1140 deg. Centigrade (2084 deg. F.).

The contract includes two 6 ft. 6 in. by 50 ft. 0 in. indirect fired rotary dryers, three 70-in. screen mills, four 8-in. pumps, and transport system for conveying the pulverized fuel from the milling plant to the boiler bins, together with feeding and burning equipment. The general furnace arrangement, showing water-cooled walls and method of introduction of secondary air, is shown in the accompanying illustration.

Principles of Power Factor Correction

CHAS G. GREEN'S article in the September 15 issue of Power Plant Engineering on the above subject is timely and is a very instructive paper; however, there are a few



VECTOR DIAGRAM SHOWING SOLUTION OF POWER FACTOR PROBLEM

points in connection with his solution which I do not believe have been gone into enough in detail to enable anyone to work out the most practical solution for the problem which he assumes.

I am attaching a rough vector diagram, which is self explanatory, but a brief discussion of the vectors may be of assistance in following the work.

OA represents the kv.a. of the system before correction and is 600 kv.a. at 60 per cent power factor. AB represents a 300-kv.a. synchronous condenser, operated at zero leading power factor, the resulting system kv.a. now being 400 and the power factor being 90 per cent. With center at A and radius AB, strike an arc BDF. Draw AD, D being the point of tangency of the arc. AD represents this same 300-kv.a. condenser operated to exert its maximum power factor correction. AC being the mechanical load carried by the motor which is 119 kw. The resulting kv.a. being 516 and the power factor now being 92.6 per cent. The reactive kv.a. is seen to be 275.

Now, if it is desired to handle all the mechanical load possible with the motor and still correct the power factor to 90 per cent, the dotted motor kv.a. vector shows this condition. The motor will handle 237 kw. with a resulting kv.a. of the system of 663, the reactive kv.a. is now 186 and the total kilowatt load 597. If it is desired that the system kv.a. does not go above 600, this 300-kv.a. motor will handle 190-kw. mechanical load and correct the power factor to 91.5 per cent. If it is desired only to correct the power factor to 90 per cent, the 300-kv.a. motor will handle 180-kw. mechanical load, the total load now being 540 kw., the kv.a. of the system remaining at 600.

In a problem of this kind the correct solution is determined by the condition for each particular case. If it is desired to carry as much mechanical load as possible on the synchronous motor, the correct solution would be to operate as indicated by the dotted lines, provided, however, the system could stand a slight increase in kv.a. On the other hand, if it is desired to have the maximum power factor correction, the correct solution would be to reduce the mechanical load on the motor and increase the power factor correction.

About the only kind of a problem where it is the most practical to float the condenser on the line is that of a transmission system, using a condenser designed for heavy field excitation and where the condenser is used for voltage regulation as well as power factor correction.

The figures as shown on the diagram are scaled off, but it is thought that they are close enough for all practical purposes.

Louisville, Ky. FRED C. DE WEESE.

Adjusting Double Eccentric Corliss Valves

RECENTLY, a nearby electric light plant received a Corliss engine with two eccentrics, and an erector from the factory was sent to install it. The operators watched the erection with increasing interest as the time came for setting the valves. These were double ported and the first of that type in town. The eccentric and hook rods had tram marks on them which had been placed there when the engine was erected in the factory. The exhaust eccentric was set first, as it came nearest the side of the main bearing, the steam eccentric being slid along the shaft toward the flywheel, out of the way.

The engine shaft was revolved in the direction it was to run until a certain point near dead center was reached. The exhaust eccentric was then revolved, until the exhaust valve for the end corresponding to the position of the crosshead, was "line to line" at the point of closing. By line to line is meant the steam edges, or "cutting" edges of the cylinder ports were coinciding with the steam or "cutting" edges of the exhaust valves. The eccentric was then fastened to the shaft and the shaft revolved until the crosshead approached the same distance from the opposite dead center. With this method, if everything is absolutely correct, the edges of cylinder port and valve port will be line to line in the opposite end of the cylinder. If not,

the rods will have to be adjusted so that both ends appear the same when the crosshead stops at the original points of travel.

The erector was asked how he determined the points where the crosshead should stop. "Well," he said, "this is a 36-in. stroke engine at 120 r.p.m. An engine at this speed requires more cushioning effect than if it was running slower. So I just imagine what sort of a compression line I would like. With the present amount of reducing motion, my indicator makes a diagram about 4 in. long. Now I will assume that my compression starts ½ in. from the end of the diagram or the equivalent of ⅛ of the total length of the diagram. Now, since the stroke of the engine is 36 in. and ⅛ of this is 4½ in., if the eccentric is so set that the exhaust valve will be line to line when closing, then, when the crosshead is within 4½ in. from the end of the stroke, the indicator diagram ought to show the compression starting ½ in. from the end."

Burlington, Iowa. TOM JONES.

Broken Packing Gland Repaired by Simple Method

WHEN the stuffing-box gland of our 150-T. vertical ammonia compressor broke, a scheme was devised to hold the packing in place temporarily. As shown in Fig. 1, this

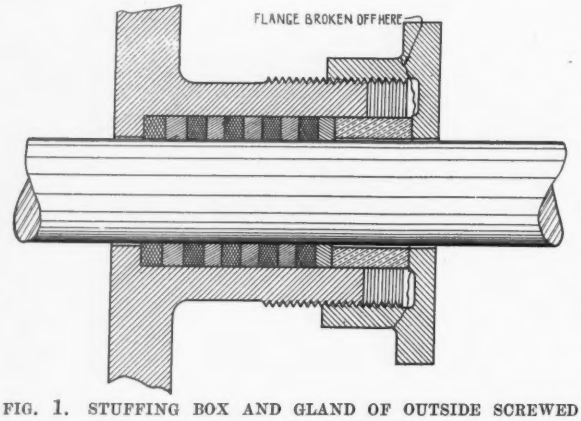


FIG. 1. STUFFING BOX AND GLAND OF OUTSIDE SCREWED TYPE FOR RECIPROCATING PISTON RODS

stuffing-box was of the screwed style and the flanged part of the gland broke off even with the bend. This repair was completed and the machine returned to service in 4 hr.

To make a quick repair, it was apparent that the studs holding the cylinder to the frame would have to be lengthened in order to provide support for a clamp under the broken gland; but as no material was at hand to provide longer studs, the same effect was obtained in another way. After removing the original nuts from the studs, extra long nuts were made from two pieces of shafting 2½ in. diameter and 3½ in. long. These were provided with 1¼-in. standard threads and then screwed on the studs where the nuts had been removed, as shown in Fig. 2. Next two 1¼-in. studs were made 16 in. long, one end having a standard length thread, while the other had a thread 8 in. long. These studs were then screwed into the lower end of the long nuts made of shafting, using the ends with standard threads. Then a clamp was made of ½ by 1½-in. flat machine steel. This clamp, shaped as shown in Fig. 2, was drilled for ⅜-in. bolts. Then two pipe nipples, ½ in. by 1½ in., were slipped over the ⅜-in. bolts in order to separate the two halves of the clamp enough to prevent their binding on the studs. This clamp was then placed under the broken stuffing-box and standard nuts screwed on the long threaded end of the studs. The gland was then

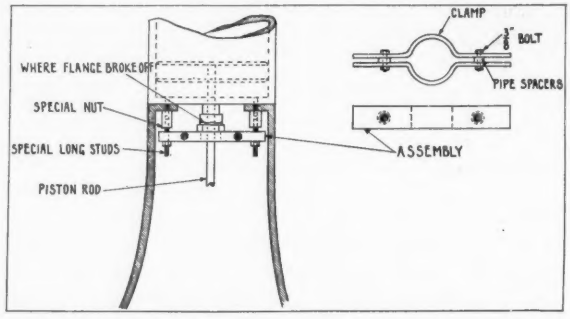


FIG. 2. BROKEN GLAND ON VERTICAL AMMONIA COMPRESSOR HELD IN PLACE BY REPAIR CLAMP

drawn up by tightening the nuts under the ends of the clamp. This gave satisfactory service for over 4 mo. until the machine was shut down for overhauling.

Kansas City, Kan. J. F. STALEY.

Valmont Points Way to Pulverized Lignite

YOUR description of the Valmont Station in the Sept. 15 issue, was unusually interesting. It shows to a striking degree the influence of local conditions upon plant design and on the choice of methods and equipment.

The fact that the steam-generated load is light in the summer and much heavier in the winter, coupled with the fact that the nature of the locally mined Colorado lignite gives a large supply of slack fuel as a practically unsalable by-product in the winter and almost none in summer, satisfactorily linked the conditions of load demand with coal supply and made lignite almost the obvious choice as a fuel for Valmont.

But the adoption of pulverized fuel as the method of firing was not as obvious and offered little in the way of precedent, especially in view of the claims of stoker manufacturers that their equipment now can handle almost anything in the way of fuel.

If a central station, having one 20,000-kw. unit and later to have more, can burn lignite successfully in pulverized form, then the way certainly should be open for a more general use of low-grade fuels. There are many states in the West and the Southwest where oil is now being burned and where no one cares to experiment with a large-scale use of lignite, even though its existence in these states is abundant. Before many more years have passed, the use of some of these vast deposits of lignite will be a matter of necessity and not of choice. The success of its use at Valmont will therefore be watched with interest.

It is also unusual that even without drying, fuel with moisture contents of 19 to 28 per cent is burned in pulverized form at this station. Some years ago the writer called attention to the results of research which showed that the reduction of moisture to a certain point decreased the cost of pulverizing fuel, but that any further drying was difficult and made pulverizing more expensive. The

work showed that the moisture content of a fuel was made up of two parts: surface moisture, which was easily driven off; and inherent moisture, which could be driven off only with difficulty.

The highest grades of coal, such an anthracite, were found to contain the smallest percentages of inherent moisture (less than 1 per cent) and for a low grade fuel such as peat, the results indicated an inherent moisture content of as much as 10 per cent. For North Dakota lignite, this value seemed to be about 7.5 per cent. A statement in your description of the Valmont plants says: "The moisture content is chiefly chemically combined, even though the coal may be powder dry and dusty upon arrival, yet the moisture content will be about 20 per cent." Of course, even with the coal "powder dry and dusty," some of the moisture will be surface, but that would still leave about 15 per cent as the inherent moisture content. This is a much higher figure than our research work indicated. It will be interesting to know whether this figure is confirmed by further experience.

Since the Bureau of Mines in Bulletin 237 states that combustion at Lakeside was found satisfactory even with pulverization no finer than 50-mesh, it also will be interesting to learn what degree of fineness Valmont will find necessary for Colorado lignite.

North Glenside, Pa. W. J. RISLEY, JR.

Steam Pipes for Low Pressure Are Often Too Small

AS FUEL continues to increase in cost, it is urgent that we pay more attention to the size of our pipe lines, particularly steam pipe lines. If there is anything that is liable to cause a tremendous waste of heat it is a steam pipe or heating coil that is too small.

Take, for example, the possibilities of use of exhaust steam. When released to the atmosphere it has a temperature of at least 212 deg. and is, therefore, capable of heating liquids and gases almost to this temperature. Seldom, however, do we find instances where exhaust steam is made to heat to a temperature of 212 deg. The method that is easiest and has the least initial cost is to use small pipes and high pressure steam for heating. The pipes are usually so small that sufficient exhaust steam cannot get in, consequently higher pressure steam is needed. The exhaust steam that should be used is wasted instead because it cannot be gotten into the small pipe line in sufficient quantity. This, therefore, may double the amount wasted at atmospheric pressure.

Sometimes, because of the small pipes that are provided for utilizing exhaust steam, back pressure is allowed to build up to such an extent that the engine capacity is greatly reduced, thus requiring the installation of an additional engine. Larger pipes for handling exhaust steam would solve these problems in many cases, yet this is a point that is seldom thought of because engineering practice has apparently standardized on comparatively small sizes of exhaust piping.

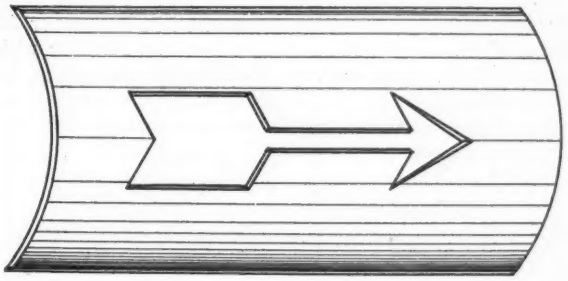
Before buying equipment that must be heated with steam, it often pays to consider using exhaust steam and to make a study of the relation between the temperature, pressure and volume of this steam. Knowing the exhaust pressure, the temperature may be found from steam tables. The volume also may be found. Then, knowing the volume, it is an easy matter to compute the size of pipe or coil needed.

Newark, N. J. W. F. SCHAPHORST.

Pipe Lines Identified by Inexpensive Method

ALTHOUGH the writer has always felt that the scheme of painting steam, water and brine pipes with identifying colors is an excellent one, unfortunately it is sometimes difficult to get plant owners to appreciate its value, possibly because they often think it is only a fancy frill, or because sometimes it would necessitate a general clean-up of the whole plant.

In several plants in which the writer has been, he encountered opposition because of the cost of cleaning and properly painting the pipe lines with identifying colors.



STENCIL FOR INDICATING DIRECTION OF FLOW AND NATURE OF FLUID IN PIPE LINES

Realizing, however, the importance of this identification, we were able to obtain practically the same result, but at little expense, by making up a simple stencil, outlined in the form of an arrow, as shown in the accompanying figure. The stencil may be made of sheet tin or copper and should be large enough to cover the general run of pipe sizes.

Instead of painting the entire piping, this stencil was applied at various conspicuous places and an arrow painted according to the pipe color chart proposed by the A.S.M.E. This scheme is shown in the following table:

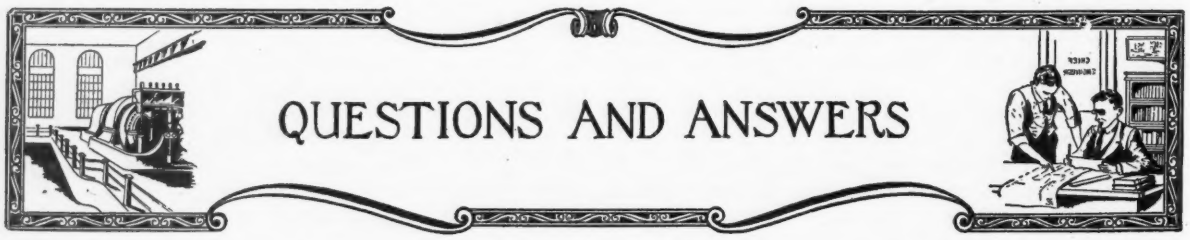
Steam	High pressure—white; exhaust—buff
Water	Fresh water, low pressure—blue; fresh water, boiler feed—blue and white; salt water—green
Compressed Air	Grey
Fuel Oil	Black
Gas	Aluminum
Refrigeration	White and Green

By using the arrow we were saved the expense of painting the entire surface and the same identification was secured, with the added advantage of indicating the direction of flow. It is more economical than painting the fittings and flange edges.

Philadelphia, Pa. M. A. SALLER.

SEVERAL YEARS AGO the City of Minneapolis started an experiment in municipally operated street lighting, installing 212 street lamps in the Tenth Ward, the electricity for which was furnished by a generator located in a garbage incinerating plant. The theory was that the cost of current was practically nothing, owing to the fact that there would be no expense for fuel. Actual operation, however, developed annual losses and unsatisfactory service.

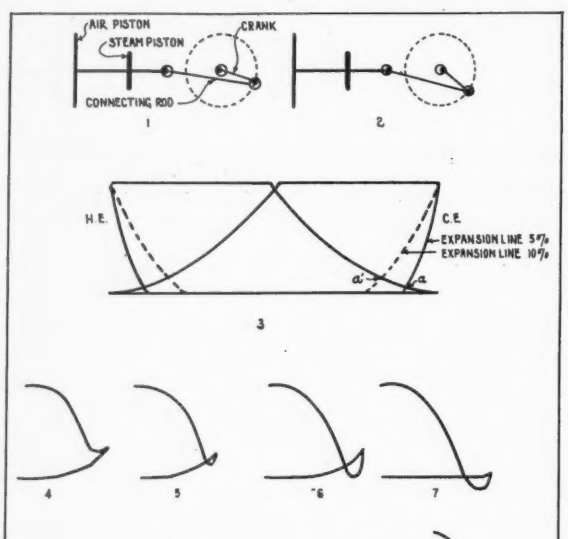
Announcement was recently made that the Minneapolis General Electric Co. has been authorized to install a new transmission system in the Tenth Ward, where it has taken over the 212 street lights formerly maintained by the city. The company also was authorized to scrap the city-owned system without cost to the city, the company to retain any materials salvaged.



QUESTIONS AND ANSWERS

Point of Steam Admission Between Two Limits

AN ENGINEER acquaintance has kindly pointed out a few statements in my letter on page 972, September 15 issue, which might tend to mislead one not familiar with these engines. Lead and compression may be regulated by



FIGS. 1 AND 2. CHANGE IN POINT OF ADMISSION CAUSES REVERSAL OF CONDITIONS

FIG. 3. INDICATOR CARDS OF AIR CYLINDER SHOWING RESULTS OF CHANGE IN CLEARANCE

FIGS. 4, 5, 6, AND 7. DELAY IN ADMISSION MAY CAUSE HOOKS OR LOOPS

FIG. 8. SHOWS CONDITIONS FOR BEST STEAM ECONOMY

FIG. 9. OPPOSITE EFFECT GIVES BEST RESULTS FOR BEARING WEAR

the engineer only within well defined limits determined by engine design. Between these limits the engineer may follow his own inclination, without seriously endangering the engine and the valve setting will be determined by the smooth running of the engine, bearing surface loads and thermodynamic considerations. More factors must be considered than in the ordinary steam engine.

Considering first the matter of late admission, it is obvious that this limit will be determined by smooth running of the engine without knocking. As shown by the accompanying diagram, in order to prevent a reversal of conditions from Fig. 1 to Fig. 2, it is necessary to have steam admission occur early enough to pick up the load before the energy of the air trapped in the air cylinder clearance space has been expended. Neglecting friction and, for the time being, the steam cylinder, with the engine on crank end dead center, the air in the clearance space will cause the piston to move toward the head end until the pressure on the two sides is equal. This will be at point A, Fig. 3, where the crank end expansion and head end compression lines cross. Up to this point the air piston would be carrying the load, the working parts bearing the relations shown in Fig. 1. It is evident therefore, that, if steam admission occurs any time in the stroke before A, the steam cylinder will gradually pick up the load and smooth running will result. If admission occurs later in the stroke than A, the load will be transferred to the flywheel for a short time, causing a knock as the working parts change position twice, from Figs. 1 to 2 and back again. The location of the point A is determined primarily by the cylinder clearance. The card outlined with a solid line is drawn for the same conditions but with 10 per cent clearance, the effect being to move point A to A' much later in the stroke.

If admission were delayed until the last possible moment, a loop or hook would probably be formed in the steam card as in Figs. 4, 5, 6, and 7, depending upon the time the exhaust valve closed and the condition of the steam valves. I have never seen an engine with valves set this way but have been informed by an old erector that it used to be a common practice and that he has indicated engines with admission so late that full steam pressure was not obtained until after 25 per cent of the stroke. Cutoff is, of course, increased accordingly and the steam expansion line raised.

Consider next early admission, as in Fig. 8, with good compression and lead enough to give full pressure at dead center, in short, a good steam engine card. In this position (dead center) the entire load of both pistons is taken directly by the wristpin, crankpin and main bearing. The unit bearing pressure will be the product of the air cylinder pressure and area plus the product of the steam cylinder pressure and area divided by the projected area of the pin or bearing.

On the engine in question with the following data: Steam cylinder, 25 in. diameter; air cylinder, 54 in. diameter; air pressure, 15 lb. per sq. in.; steam pressure, 150 lb. per sq. in.; receiver pressure, 6 lb. sq. in.; main bearing, 15 in. by 28 in.; crankpin, 7.5 in. by 8.5 in.; wristpin, 7 in. by 8.5 in.; the air piston load would be $15 \times 3.1416 \div 4 \times 54^2 = 34{,}300$ lb., the steam piston load would be $(150 - 6) \times 3.1416 \div 4 \times 25^2 = 70{,}500$ lb. or a total load of 104,800 lb. on the piston rod, giving unit bearing loads of $104{,}800 \div (15 \times 28) = 249$ lb. per sq. in. on the main bearings, $104{,}800 \div (7.5 \times 8.5) = 1640$ lb. per sq. in. on the crankpin and $104{,}800 \div (7 \times 8.5) = 1760$ lb. per sq. in. on the wristpin. These pressures are only

momentary as the crank passes dead center. If the load and compression changed to that of Fig. 9, giving a steam or compression pressure of about 46 lb. at dead center, the unit bearing loads in pounds per sq. in. will be reduced to 128 for the main bearing, 845 for the crankpin and 910 for the wristpin.

Admission therefore is fixed between two limits determined principally by the air-cylinder clearance volume and the bearing areas. In the interest of steam economy, it is advantageous to get as close to Card 8 as possible in order to reduce steam cylinder condensation and clearance losses. In the interest of bearing wear, it is advantageous to go in the opposite direction. Just how far one may or should go in either direction seems to be a much debated question. As a rule, engines built in late years may be given more lead than the older ones and, I understand that since the advent of the uniflow cylinder for this service, at least one manufacturer makes it a practice to build all engines so that any desired lead or compression may be carried. Frame loads are also important but, usually, the factor of safety is large enough so that they are safe until after the bearings are greatly overloaded.

The engine used in the illustration was built about three years ago but, in spite of its recent design, shows high crank and wristpin pressures as the lead is increased. The valves as set, however, keep these down to a conservative value.

I trust that my original request for criticism of the cards published will not be mistaken but considered as a genuine request for information and interest in any discussion that may come up. The question has been talked over many times with erectors, engineers, salesmen, master mechanics and operators from various manufacturers and mining camps, always, of course, centering about this type of engine as the one in which we are most concerned. It was not until after the first cards had been published and answered that I began to realize that this type of engine is confined to a comparatively small group of industries, with which the great majority of engineers do not come in contact. This is a summary of conditions as I understand them for the information of those who are not familiar with and have not had the opportunity of studying this type of machine. I trust it will lead to some interesting discussions regarding a question upon which, in many cases, operators have definite ideas without any logical reason.

Clarksdale, Ariz. RICHARD H. MORRIS.

Higher Superheat Needed to Get Dry Exhaust

WE ARE contemplating the installation of a steam turbine to run non-condensing against 15 lb. back pressure (gage). The steam pressure will be 175 lb. (gage) with 100 deg. superheat. We would like to know what the quality of the exhaust steam would be under these conditions. Could we have high enough superheat to have practically dry steam in the exhaust at 15 to 25 lb. back pressure? L. L. B.

A. You have not given enough information to figure the quality of the exhaust steam from your turbine since you have not stated the size of the turbine nor the water rate.

Also, the efficiency of the generator and the amount of radiation loss are needed. It is possible, however, to give a formula for figuring the quality of the exhaust and illustrate with an example:

Suppose that a 1500-kw. turbine operates non-condensing with steam at 175 lb. gage, or 190 lb. absolute, with 100 deg. superheat and with exhaust at a back pressure of 30 lb. absolute; the water rate of the turbine to be 30 lb. per kw-hr., the generator efficiency 90 per cent and the radiation loss 5 per cent.

The quality of the exhaust may be figured by using the following formula:

$$X = H - \text{kw.} \times 3413 \times (1 + M) \div (W \times E)$$

where

X = B.t.u. per lb. of exhaust steam

H = total B.t.u. per lb. of steam entering the turbine

W = total steam condensed per hr. or (water rate $\times$ kw.)

M = external losses due to radiation and convection. M is stated in terms of turbine output and varies from 1½ to 3 per cent for large units, while on small, uninsulated, non-condensing turbines with superheat it may be 8 to 10 per cent.

E = Generator Efficiency

Substituting in the foregoing formula, we then have

$$X = 1256 - 1500 \times 3413 \times 1.05 \div (45{,}000 \times 0.90)$$

This gives

$$X = 1123 \text{ B.t.u.}$$

Then, referring this figure to the Mollier diagram, the quality of steam at 30 lb. absolute pressure is 95.7 per cent. This should give you an idea of how to work your problem and you can substitute your own figures in the formula. From this it may be seen that the amount of superheat in the initial steam will have to be increased to get dry saturated steam in the exhaust, provided thicker insulation is supplied to maintain the radiation loss at the same figure.

Scavenging in Diesel Engines

WHAT IS meant by the term "scavenging" as applied to Diesel engine practice? A. R.

A. Scavenging is the process of cleaning or purging the cylinders of burnt gas after every working stroke. At the end of every outward or power stroke of the pistons, the exhaust ports open and the burnt gases escape, reducing the pressure within the cylinders to that of the atmosphere. Practically at the same moment the scavenging ports are opened and a blast of clean cold air from the scavenging pump sweeps through the cylinders from end to end.

Efficient scavenging is one of the secrets of success of the Diesel engine over the gasoline engine. There must be complete removal of all burnt gases after every working stroke if the power of the engine is to be maintained. The washing out of the cylinders and exhaust ports with cold air immediately after they have been subjected to the temperature of the hot gases also has a beneficial effect on the cooling of the working surfaces.

Cleaning Brass and Nickel

ON SEVERAL of our pressure gages, the brass rims have become so dull and tarnished that we have been unable to get them clean. What should we do?

E. A. R.

A. A strong solution of potassium cyanide will clean brass, copper or nickel, but care should be taken to rinse the hands thoroughly, as this solution is a deadly poison.

Condensate from the World's Power Plant

ANALYZED FOR QUICK STUDY AND COMPARISON. BY WILLIAM SIBLEY

Why Not Let Experience Teach Us?

The Federal Budget for 1925 calls for an expenditure of $3,079,000,000. That enormous total is made up of many separate items, the three largest of which are:

$865,000,000 interest on the public debt.

$559,000,000 to care for the disabled soldiers.

$472,000,000 sinking fund, to look after future payments on public debt.

These three items all grew out of the world war. The first and largest item will be largely reduced when Europe begins payment on her indebtedness. The last named will be reduced as the Liberty bonds are retired.

Other interesting items found in the budget are $344,000,000 for the Army; $338,000,000 for the Navy; $217,000,000 for Civil War and Spanish-American War pensions.

The head of the Budget Bureau wants to shave $10,000,000 from the Army appropriations for 1926, apparently overlooking the fact that the six largest items in our budget are all war expenses—incurred because we have consistently refused to learn the lessons of war.

General Pershing, at the close of the World War, worked out a careful and economical program for national defense. His plan called for a mere skeleton of an army—low in numbers but high in intelligence—around which a national armed body could be built in time of emergency and need. That plan was adopted through the passage of the National Defense Act of 1920. It originally called for 576,000 men, but Congress cut that number to 280,000. In 1923 Congress further cut the Army to 150,000 men and reduced it to 127,000 in 1924, at which point it now stands.

Congressmen who forced these cuts said that other countries would follow our lead and reduce their armies in like proportion. In this we have been disappointed. Other armies are as large as ever, three national armies actually having grown.

Some senators and members of the house are going to advocate the further reduction of our standing army to 100,000 men, during the coming session.

With our outlying posts in Guam, Panama, Alaska, Hawaii, Philippines and the islands of the Atlantic—with our population of 112,000,000 and our wealth of $300,000,000,000—is not an army of 127,000 men quite the minimum? Never in its history has the United States gone longer than 34 yr. without a war. Can we not learn from experience how to minimize the frequency of war and reduce the consequent expense of warfare? Is ten or twenty millions an economy, when that sum brings with it the liability of an expenditure of uncounted billions?

Operating Efficiency vs. Equipment Efficiency

Operating and production costs can be reduced in two ways—by improvement in physical equipment and by improvement in methods of operation. Determination of the money and effort to be expended on each of these two ways is the duty of every industrial executive.

In an interesting study of percentages, A. A. Beckwith, industrial research engineer, gives the following figures: "Let us consider a plant whose equipment, perfectly operated, is capable of 85 per cent efficiency as compared with the best to be had in the market. If the operating force is handling the plant at 65 per cent efficiency as compared to the best of which it is capable, the net output will be 0.65×0.85, or about 55 per cent of the best possible achievement with the best possible equipment.

"If the operation can be improved so as to get 100 per cent operating efficiency, the output will jump to 85 per cent of the best possible, an increase of 30 per cent.

"If the best possible equipment is installed without improving the operation efficiency, the output will be 0.65×100 or 65 per cent, an increase of only 10 per cent in output. This increase has to be paid for by new expenditures for equipment, whereas the improvement in operation can be effected with negligible increase in outlay, since the cost for 100 per cent workers and methods is but little more than for 65 per cent operation."

These figures may be extreme but they serve to show why one plant, with poorer facilities than its neighbors, can still show lower production costs.

We have plants which are equipped with many automatic features but have not yet reached the point where they can be operated without the aid of men. Let us not overlook the human factor in the search for mechanical perfection.

Our Most Influential Agency for Good

Although it may be said that the Red Cross movement had its origin in the Battle of Solferino, in the Italian War of 1859 (the movement growing out of Henry Dunant's book *Un Souvenir de Solferine*), it remained for Clara Barton to interest President Garfield and James G. Blaine, then Secretary of State, in the ratification of the Treaty of Geneva. Official ratification was not made, however, until 1882 when Chester A. Arthur had succeeded to the Presidential Chair following the assassination of President Garfield. Immediately upon formal adhesion to this compact The American Association of the Red Cross was incorporated under the laws of the District of Columbia, with Miss Barton as its president.

The American Red Cross is the only volunteer society authorized by the Government to render aid to its land and naval forces in time of war. The charter of the Red Cross defines its purposes as: "—to furnish volunteer aid to the sick and wounded of armies in time of war; to act as a medium of communication between the people of the United States and their Army and Navy; to continue and carry on a system of national and international relief in time of peace, and to apply the same in mitigating the suffering caused by pestilence, famine, fire, floods or other great national calamities and to devise and carry on means for preventing the same."

As a governing body the American Red Cross has a Central Committee, composed of eighteen members, six of whom are elected by the Board of Incorporators, six representatives of Chapters, and six appointed by the President of the United States, representative of the Departments of State, War, Navy, Justice, Commerce and the

Treasury. According to the by-laws, the President of the United States is always president *ex-officio* of the American Red Cross.

During the late World War, the American Red Cross organized and completely equipped 54 base hospitals, each with a bed capacity of 1000; 19,877 nurses were assigned to active military duty, more than 10,000 of whom served over-seas. In domestic cantonments they served refreshments 40,000,000 times to troops in transit, and 15,376,000 times to soldiers in France. In the United States, during the war period, they provided financial assistance and other forms of social service to more than 500,000 families. All of this service cost the Government not a penny.

Now, the American Red Cross is back at its peace time work of giving assistance to suffering humanity—stamping out contagious disease, teaching sanitation and health and rendering relief to the unfortunate victims of disaster. To help carry on this work it will ask you, the week of November 11th, for one little silver dollar. What are you going to do about it?

It Pays to Promote Thrift Among Employes

Statistics show that the period of greatest productivity for the average man is between the ages of 30 and 55. Unfortunately, the average man fails to provide for the following years of lower productivity, with the result that many, at the age of 65, are again quite as dependent as they were at the age of 15.

Much of this inadequate provision can be remedied if salaried employes learn the value of planned expenditures. Rigid adherence to a carefully worked-out individual budget will bear savings-bank fruit in an astonishingly brief time. It is, of course, quite impossible to formulate budgets for all employes or all conditions. The type of individual, location of the plant, available facilities and existing conditions are governing factors. Tentative budgets have been prepared, however, with some degree of success and some firms had a gratifying degree of response to the suggestions.

Recently the writer visited a large industrial plant in Cleveland where they have employed this idea, with some expansion, to distinct success. Budget forms are printed on the backs of the pay envelopes and serve as a constant reminder to the men of the necessity for strict adherence to a definite plan. This firm enters into an agreement, with any employe wishing so to bind himself, that it will give him $500 when he can show a savings account totaling $1000 which has been accumulated out of actual earnings. This $500 is given, however, with the stipulation that the entire $1500 will be spent in the purchase of a home. The budget this firm used is as follows:

SINGLE PERSON

Board and lodging, including lunches and car-fare..50%
Clothing, including laundry, pressing and repairing..20%
Recreation, education and advancement.....15%
Savings 10%
Incidentals 5%

FAMILY BUDGETS

Food 20%
Shelter, including taxes, rent, interest on mortgage, upkeep of home, etc.....20%
Maintenance, including running expense, gas, service, electricity, etc. 15%
Clothing 17%
Recreation and advancement, including church, charity 13%
Saving 10%
Miscellaneous 5%

It is interesting, as a side-light on the success which this firm has met in carrying forward the plan, to find that it has assisted in the purchase of more than 200 homes and that, since the inauguration of this plan, the labor turn-over has decreased nearly 75 per cent. The management believes that the $500 bonus for assured savings is an expenditure much less than would be required to hire and train a new man under the old, high turn-over system.

Next Year's Crops Liable to Be Damaged by Present Drouth

In thirty-five states of the Union the rainfall since January 1, 1925, has been from 10 to 65 per cent below normal. The area which has suffered the most from the drouth is the territory extending south from Missouri to Texas and eastward through southern Illinois, Indiana, Ohio to Pittsburgh and embracing all the area southward to Florida and the Gulf of Mexico. With few exceptions in isolated regions, no drouth has been experienced in New England, nor in Montana, Idaho, Utah and California.

Had it not been for a singularly fortunate distribution of the small rainfall, the crops of the Corn Belt would have met with serious disaster. As it is, the July 1st estimate of the corn crop, which was for 3095 million bushels has been reduced only slightly, the September estimate being for 2885 million bushels. Damage to the hay crop and pastures, however, has been great and, in several sections, stock was put on winter feed early in August.

Conditions throughout the South have been most serious. Not only has the lack of rainfall quite seriously damaged the cotton crop but lack of water to supply the power companies has made it necessary to curtail cotton-mill operations in certain localities. Municipalities, here and there, have been obliged to put into effect rigid restrictions as to the use of domestic water and many of the smaller towns have been hard put for drinking water.

Records show the drouth of 1925 to be the most serious of any experienced in this country since 1890. We need rain and we need it badly—not only for present requirements but to bring the ground water to normal levels for the assurance of a favorable start for 1926 crops.

Where many steam traps are used in a plant, it will pay to have somebody whose duty it is to make frequent, periodic inspections, to detect leakage or improper operation.

For underground steam mains, location of the flanged joints should be marked in some way on the surface, by mark on the pavement, by driving a steel rod or by setting an identifying stone. This will save much labor in case it becomes necessary to inspect or repair the piping.

Every fireman should make it a first duty when coming on watch to blow down the water glasses and water columns and try the gage cocks of each boiler. He is then sure that all the connections are clear and that there is the proper amount of water in the boilers.

Cast-steel rather than cast-iron valves should be used where there is superheat of 80 deg. or more.

Waterproof covers for machinery and stock, to protect from overhead sprinklers, often effect a great saving of time and material.

EDITORIAL COMMENT

Low-Temperature Carbonization Offers Economic Possibilities

During recent years considerable attention has been given to low-temperature carbonization of coal as a means of reducing fuel costs. This process has been developed farther in Europe than in America, due undoubtedly to the greater scarcity of fuel there than here but, if found practicable, American engineers should give it careful consideration as a means of reducing their fuel costs.

As a start in this direction, Power Plant Engineering presents in this issue the first of a series of two articles dealing with low-temperature carbonization and its application to American industries. These articles have been prepared by H. W. Brooks after an investigation of European practice which he conducted for the U. S. Bureau of Mines.

In applying his observations there to American conditions, he draws conclusions which, while somewhat at variance with those reached by others, seem to offer more immediate practical possibilities for economically feasible installations in America than many of the proposals of the past. He feels that once the initial economic inertia, always confronting any new technical accomplishment, is overcome by a money-making demonstration of its feasibility in connection with central station operation, the future will eventually demonstrate whether semi-coke is more valuable in the form of electricity or as a smokeless domestic fuel. His figures indicate that the utility operator may profit handsomely in the meanwhile and at the same time be prepared to take advantage of the future situation, whichever way it may develop.

Commercial scale installations of low-temperature carbonizing equipment in connection with large power stations are already in operation in America, England and Germany, the coke being burned on chain grate stokers instead of in pulverized form, hence probably not giving as efficient a conversion to electricity as that proposed by Mr. Brooks in his articles.

While the problem of securing coal for industrial purposes has not become acute in America, engineers are not averse to changing their methods when economic conditions warrant.

Support the Simplified Practice Movement

It would seem that the present movement to reduce and simplify varieties and sizes of industrial materials, now being carried on under the supervision of the Division of Simplified Practice of the U. S. Department of Commerce, will prove to be one of the most important industrial developments of the present year, provided it moves on to its ultimate goal, as we have no doubt it will. Announcement comes, for example, that varieties of hollow building tiles have been reduced from 36 to 19, common brick from 44 to 1, rough and smooth face brick from 75 to 2, metal lath from 125 to 24 and so on through a list of forty or fifty items, the reductions having been approved and accepted by the various manufacturing groups that produce these materials. Recommendations for the simplification of hundreds of other products, ranging from hospital beds to milk bottle caps and plow bolts, have been made and the manufacturers will be asked to approve and carry out these plans.

To industry as a whole, this means the first step towards a standardization of engineering material that will lead to better manufacturing processes, lower costs and stabilization of the whole industrial structure. It will eliminate bad imitations of good products and will stimulate competition, as there will be a constant impetus for competing firms to develop new products on sound engineering lines that can be included in the list of standards or to devise methods of improving existing products and of still further cutting down useless duplication.

Reports from other countries that are among our keenest competitors in foreign trade indicate a great and increasing interest in standardization and simplified practice. These reports have led to a feeling of uneasiness among American manufacturers that European firms will work out their own methods of simplified practice and will then proceed to establish standards that will be imposed on the rest of the world to the exclusion of American standards. There would, of course, be some danger of this, if we were to assume that progress in simplifying practice and fixing standards were to come to a standstill in this country at once. But this cannot be, for more and more manufacturers are coming to realize that the best interests of every industry will be served by co-operating in the splendid work being done under the direction of Secretary Hoover's department.

Nearly 400 industrial groups are receiving the co-operation of the Division of Simplified Practice in weeding out the superfluous; forty of them have definitely approved recommendations to that end. Progress is being made, even with this comparatively small group but this progress is small compared with that which would certainly result from the concerted efforts of every manufacturer, every trade association and every agency interested in educating men for engineering or business.

We strongly urge that every engineer and every industrial executive take steps if he has not already done so, to co-operate with the Division of Simplified Practice and to investigate the possibilities of eliminating superfluous varieties of the materials produced by his industry for a concerted effort on the part of American industry is needed. The simplification movement is gaining momentum every day and we have every confidence in its ultimate success.

WHEN ONE becomes angry his intelligence rarefies. The more rarefied an intelligence becomes, the more sensitive it is to its relation with its superior—the intelligence that has remained unangered.

Boiler Plant Operation Number

JANUARY 1, 1925, ISSUE WILL DEAL WITH MODERN STEAM GENERATING EQUIPMENT AND APPROVED METHODS OF ITS OPERATION

IN AIDING engineers and plant managers to improve their boiler plants, Power Plant Engineering feels that it is contributing materially to the reduction of power waste and to conservation of our fuel resources. With this end in view, it is preparing the Boiler Plant Operation Specialized Number.

HANDLING STOKERS AND PULVERIZED FUEL EQUIPMENT

Stoker operation is given first place in the number because stoker installations are becoming more and more common. This section deals with the handling of stokers from the starting of the fires, through the carrying of the load to the banking of the fires. Control of the fuel bed thickness, rate of feed, air supply, flue-gas analysis and temperatures, air preheating and removal of clinkers and ashes are subjects covered in this section. Special detailed instructions will be given for the operation of the various types of stokers now in use in boiler furnaces.

Pulverized fuel has, within the past few years, become of prime importance in the power plant field and, as its use is growing rapidly, a section of the number is devoted to methods of handling pulverized fuel furnaces.

The course of operation will be followed from starting to shut down, dealing with fuel and air supply control, checks on furnace performance by flame, temperature and chimney gas indications.

Preparation and handling of the fuel will be fully covered, treating of removal of foreign matters, drying and pulverizing, storage and transporting and special precautions required for safety.

OIL BURNING AND HAND FIRING

Oil fuel burning will be given thorough consideration as to all phases of the system including starting up, control of fuel viscosity and supply, care of burners, control of air, checks on combustion conditions and storage and handling of fuel.

Because of the great opportunity for salvaging dollars in the many hand-fired boiler plants of the country, close study will be made of the requirements to get best results for various kinds of fuels and with the different forms of settings and grates to be found in use. Thickness of fire to be carried, frequency of firing, keeping fuel bed in best condition and treatment for high-volatile, coking, caking and low-grade fuels will be considered. How best to use dampers, ash-pit doors and firing doors to control air supply, methods of judging fire conditions, indications of draft gages, smoke indicators, CO_2 measurements and temperature indications will be treated.

BURNING WOOD WASTE

In many plants, all or a substantial part of the steam is made by using wood waste as fuel. Where the wood meets only part of the fuel needs, better use of the fuel will result in a saving in coal to be bought. Methods of feeding wood, alone and in combination with coal, proper grates and furnaces and the handling of fires and draft to get best results will be taken up fully in this section.

Draft control varies, of course, according to fuel used, furnace and means available. Damper regulators and draft fans, pressure and exhaust are the usual means. Secondary air supply, to insure complete burning of gases is of prime importance and the method of providing this for grates, stokers, pulverized fuel, oil and wood waste, in order to get maximum efficiency, will be discussed.

FEED WATER TREATMENT AND REGULATION

Methods of purifying feed water, including straining, heating, chemical treatment, the Zeolite process, evaporation, deaeration and filtering of condensate will be subjects carefully treated.

Steady feed of water to boilers in proportion to steam output is an essential of good operation. Boiler feed and its control by means of centrifugal and reciprocating pumps as driven by motors, steam turbines, mechanical power or direct steam pressure will, of course, be given adequate space.

In economizer operation, proper relations must exist between water flow and gas flow so that temperatures may be kept within proper limits. The economizer surfaces must be in good condition to transfer heat. Frequent inspections must be made and tubes, headers and housing kept up so that safety will be assured and leakage avoided. The section on economizer practice will cover all these essentials.

MAINTENANCE OF BOILER PLANT EQUIPMENT

One section will be devoted to boiler upkeep in which methods of inspection, where to look and what to look for, how to replace tubes, to apply patches, to repair settings and valves, to keep water and steam gages in condition and how to make emergency repairs, so as to keep going temporarily will be topics for consideration.

Grates, side walls, arches and bridge walls are subjected to trying conditions, especially under modern practice of forcing boilers far above rated capacity. Regular cleaning, early patching and arrangement of furnaces to protect linings against excessive heat will help in cutting costs.

Superheaters, like boilers, must be kept clean, inside and out, and the tubes must be guarded from injury. A section of this issue will show how to secure best results from superheaters.

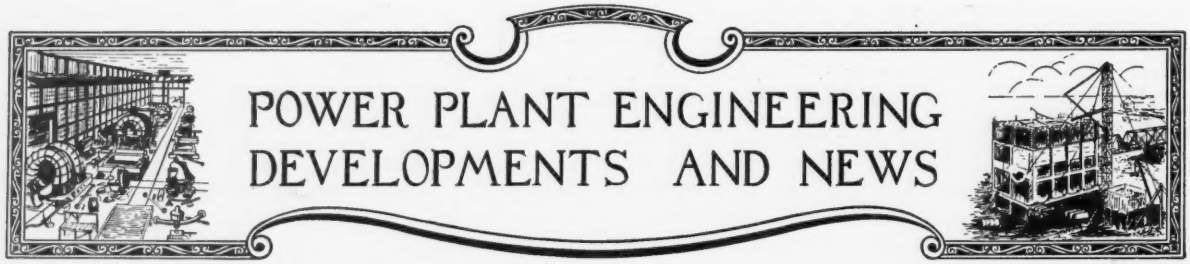
That the pumps in a plant may give best service, the valves must function properly and close tight, pistons, plungers and rods must be kept packed so that leaks will be prevented but excess friction must also be avoided, bearings must be in good condition and proper lubrication supplied.

The section on ash handling will consider how to keep the mechanical ash man in energetic action at all times. It will also point out that his load should be investigated rather frequently to find out how many heat units he is carting away in the form of unburned fuel.

PLANT MANAGEMENT

Steam control involves a study of the proper supply and location of steam valves, provision for drainage of piping and systematic routine for cutting boilers into and out of service. Also, it is important to know what each boiler is contributing to the output and here flow meters give the needed data. Types of these meters and their care will, therefore, be included.

Each of the subjects of stack maintenance, routine tests and boiler room management will be treated in separate sections of the Boiler Plant Operation Number which is being prepared as a comprehensive, up-to-date text and reference book.



Columbia Power Station Begins Operation Nov. 12

COLUMBIA GAS & ELECTRIC CO. INSTALLS TWO 45,000-KW. TANDEM-COMPOUND TURBINES, WITH STAGE FEED HEATING AND REHEAT BOILERS, AS FIRST UNITS OF NEW PLANT

ANNOUNCEMENT HAS just been made by the Columbia Gas & Electric Co. that its new plant, originally known as the Miami Fort Power Station, but recently renamed Columbia Power Station, expects to place its first units in operation on Nov. 12, 1925. This plant, designed at present to contain two 45,000-kw. turbo-generators, is planned so that six or eight additional units of the same capacity can be installed as conditions warrant. Tandem-compound turbines with high and low pressure cylinders on the same shaft, reheat boilers, 550 to 600-lb. steam pressure, air preheaters, and stage feed water heating are among the interesting features of the new station, which is reported to be the first to utilize all of these developments in one installation.

At the formal dedication of Columbia Power Station, Owen D. Young, chairman of the board of directors of the General Electric Co., will deliver an address, which will be broadcast by Station WLW. Miss Virginia Junggren, daughter of the designer of the 45,000-kw. turbo-generators, will officially turn on the steam, assisted by Charles P. Taft, of the executive committee of the Columbia Gas & Electric Co.

Columbia Power Station is located on the Ohio River about 20 mi. west of the center of Cincinnati, Ohio, and ¾ mi. east of the mouth of Great Miami River. Although only 100 acres of land were required for the generating station, the company owns about 1500 acres of land surrounding it, on which an industrial community is expected to develop, as water and rail transportation and power are extremely convenient. An employe's village, with the usual school and club house facilities, has been constructed on the hills behind the station.

Two 45,000-kw., tandem-compound turbo-generators shown under erection in Fig. 2, form the first generating units at Columbia Power Station. These turbines have 14 stages in the high-pressure cylinder and 12 stages in the low, operating at an initial steam pressure of 550 lb. gage at the throttle, 245 deg. F. superheat and a total steam temperature of 725 deg. F.; the units exhaust at an absolute pressure of 1 inch of mercury. An initial pressure of 600 lb. and 750 deg. total temperature can be employed if necessary and the 45,000-kw. rating of the units has been based on these conditions. Steam at 120 lb. absolute, 424 deg. total temperature, is extracted from the 14th stage and passes to the reheat boilers, from which it is returned at 110 lb. pressure and 725 deg. total temperature to the 15th stage, the first stage of the low-pressure cylinder. Operating at full load without extraction, the turbine is designed for a water rate of 7.67 lb. per kw-hr.

Boiler equipment consists of six standard and two reheat boilers to drive the two initial turbine units. Standard boilers have 15,110 sq. ft. of heating surface and the superheaters 2640 sq. ft. of heating surface, superheating the steam to 740 deg. F. at 570 lb. gage. Each reheat boiler consists of a 6060-sq. ft. section with a 1610-sq. ft. superheater, with a 17,275-sq. ft. reheat section mounted above it, reheating the steam from the 14th stage to 725 deg. total temperature. Standard and reheat boilers are each equipped with a wrought steel, 7300-sq. ft. economizer. Each boiler is equipped with a tubular air heater of 9888.5 sq. ft. heating surface. Four extraction feed water heaters, as shown in the accompanying table, are installed, together with deaerators.

Condensers are of the vertical, inclined type, of 48,000-

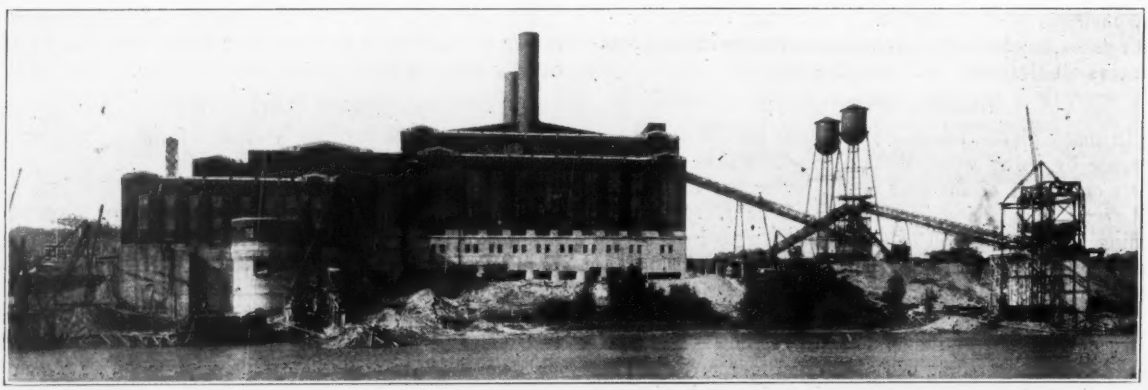


FIG. 1. THIS VIEW OF COLUMBIA POWER STATION TAKEN SEPT. 25, 1925, SHOWS PLANT UNDER CONSTRUCTION

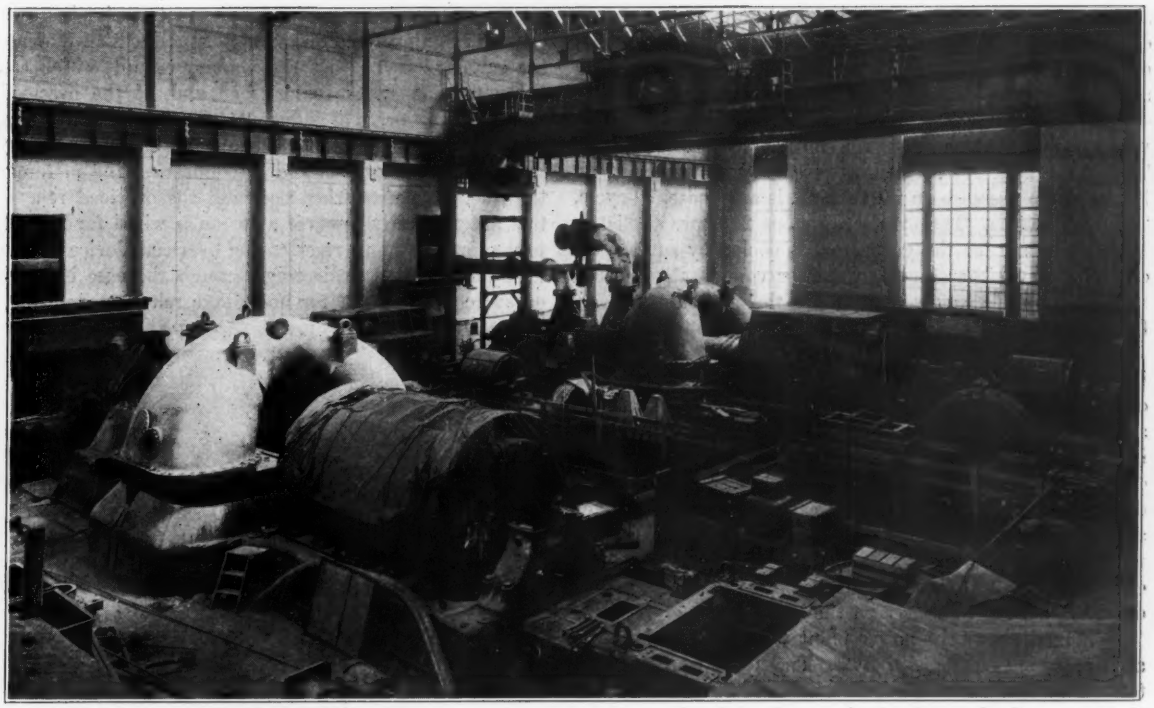


FIG. 2. TWO 45,000-KW. TANDEM-COMPOUND TURBO-GENERATORS UNDER ERECTION AT COLUMBIA POWER STATION, AS THEY APPEARED ON SEPT. 25, 1925

sq. ft. capacity. The circulating pumps for each condenser are two 30-in. horizontal centrifugals, the two pumps delivering 60,000 g.p.m. against 27-ft. head, and driven at 360 r.p.m. by 2300-v., squirrel cage motors. Primary hot-well pumps are 6-in., two-stage centrifugals of 800-g.p.m. capacity each against 175 ft. head, driven by 100-hp., 1200-r.p.m., 2300-v. slip ring motors.

Non-condensable gases are removed by hydraulic vacuum pumps, hurling water for which is furnished by two 8-in., motor-driven centrifugal pumps. Each condenser also has a 6-in. sand pump. When supplied with 60,000 g.p.m. of 60-deg. water, these condensers are designed to maintain an absolute pressure of 1.05 in. of mercury.

Condensate is pumped by the primary hot-well pumps through generator air coolers to the low stage heaters, the discharge from these heaters then going to secondary hot-well pumps, which pump the water through the intermediate heater and gland heater to the open feed water heater. From the latter, water flows to the deaerators at 240 deg., leaving them at 215 deg. The pressure in these deaerators is 15.6 lb. absolute, non-condensable gases being discharged direct to atmosphere. In case the temperature in the deaerators should fall below the predetermined limit, two vacuum pumps are cut in automatically.

Coal received at the plant, either by rail or by water, may be delivered to the crushing tower immediately upon its arrival and after crushing may be sent either to the coal preparation plant or to the initial storage pile. Storage space has been provided for 122,000 t. of coal, either run of mine or crushed, which is reclaimed by a drag scraper. The coal handling equipment has a capacity of 250 t. an hour.

From the crushing tower the coal goes to the preparation plant, adjoining the boiler room on the east, where it is dried in two 6-ft. by 50-ft. indirect pulverized coal fired rotary driers, pulverized by six 57-in. gear driven, screen type mills and transported to the individual boiler hoppers by three 6-in. and two 10-in. pumps. From the boiler hoppers, the pulverized fuel is fed by triplex coal feeders to the nine vertical flare type burners and six horizontal flare type burners with which each boiler is equipped.

This fuel burns under each boiler, in a 12,391 cu. ft. furnace, at the rate of 18,000 lb. of coal per hr., the heat liberated being 16,700 B.t.u. per cu. ft. of furnace volume, with 12,000-B.t.u. coal. Each boiler has 45 secondary air inlets. Air for combustion is heated by the tubular air heater and then passed through the side wall by ash pit cooling passages. Primary air is heated by the ash pit passages, secondary air by the side wall passages. Forced and induced draft fans have duplex motor drive.

Boiler Feed Pumps Have Both Motor and Turbine Drive

Four motor-driven, horizontal centrifugal boiler feed pumps and two steam-turbine driven centrifugal boiler feed pumps are installed. The former are six-stage pumps, each one direct-connected to a 400-hp., 2300-v., 1800 r.p.m., slip ring motor and delivering 400-g.p.m. against a total head of 680 lb. Turbine driven pumps are

TABLE SHOWING TEMPERATURES AND PRESSURES IN EXTRACTION FEED WATER HEATERS

Heater	Type of Heater	Per cent Extraction	Pressure Lb. Abs.	Water Temp. Deg. F. In	Out
24th stage	Vert. open	5.41	2.95	75	130
22nd stage	Closed	2.80	9.70	130	173
Gland	Closed	1.38	14.00	173	195
18th stage	Open	2.61	40.00	195	240

six-stage, are direct connected to 340-hp. turbines and deliver 500 g.p.m. against a head of 680 lb. These turbines operate at 2500 r.p.m., initial steam pressure 550-lb. gage and exhaust at 10 lb. into the open feed water heater.

Main generator, auxiliary generator and exciter of each unit are mounted on the main shaft, as shown in Fig. 2. The main generator, rated at 45,000 kw. with 600-lb. initial steam pressure on the turbine, is a 3-phase, 60-cycle, 2000-v. machine. The exciter develops 270 kw. at 250 v. Ventilating air for the generators is cooled by surface air coolers, using either service water or condensate in their main sections. Fire protection for the generators is afforded by injecting inert gas through the cooling air ducts.

Condensing water is brought through traveling screens in the crib house into the intake tunnel, which, with the discharge tunnel, runs under the switch house parallel to and west of the turbine room. The tunnels, as originally installed, are large enough to serve the ultimate installation of six or eight 45,000-kw. units. A 48-in. vertical, motor-driven centrifugal pump, with a capacity of 60,000 g.p.m. against a head of 15 ft., is located in the crib house and will pump water from the discharge tunnel through a cast iron pipe to the mouth of the intake tunnel to melt drift ice that might collect on the screens.

Figure 1 shows the power plant viewed from the river, as it appeared on Sept. 9, 1925. The north wall will be a temporary one, but will be constructed of the same brick as the rest for the building. This exterior brick is a mottled red, wire-cut brick; the steel window mullions will be painted green. The interior of the turbine room will be cream grey brick, with a wainscoting of dark ivory tiling and a green tile floor.

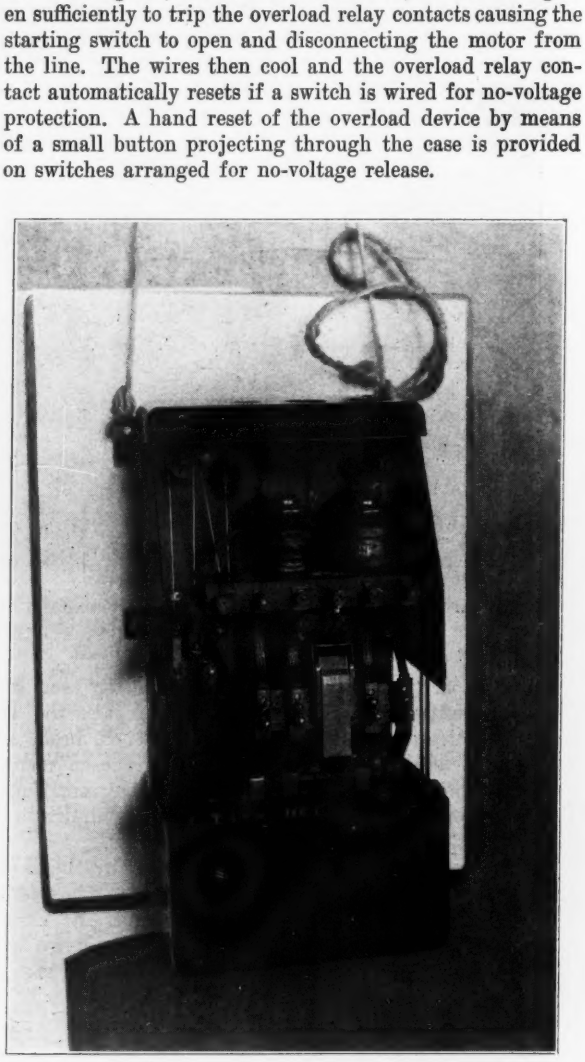
Sargent & Lundy, Engineers, of Chicago, designed Columbia Power Station, co-operating with the engineers of the Columbia Gas & Electric Co.

New Starting Switch for Induction Motors

FOR USE in connection with squirrel cage induction motors, the Electric Controller and Mfg. Co., of Cleveland, O., has recently developed a new type of push button operated oil switch by means of which such motors may be started directly across the line.

This device known as the type ZO Starting Switch is controlled by one or more push button stations located at convenient points. The switch proper shown in the accompanying illustrations, is provided with four pairs of heavy contact fingers—three of which handle the main line in the care of three-phase or two-phase, three-wire motors while the fourth pair handles the control circuit to the push button when the switch is arranged for no-voltage protection. In the case of two-phase four-wire switches all four lines are disconnected in the "off" position when the switch is wired for no-voltage release.

A novel feature of this switch is the inverse time element temperature over load device. This consists of two alloy wires each attached at one end to an adjusting screw, and at the other end to a multiplying lever which operates a quick make and break contact, the wire being connected across the secondary of a small current transformer. The gage of the expansion wire and the winding of the secondary of the transformer remains the same regardless of the horsepower ratings or voltage of the switch. The size of wire and number of turns of the primary are proportioned to suit the rating of the motor. An increase in current or an overload on the motor produces an increase in the current flowing in the secondary circuit, which causes the expansion wires to lengthen and, if the overload is severe enough or, is of sufficient duration, the wires lengthen sufficiently to trip the overload relay contacts causing the starting switch to open and disconnecting the motor from the line. The wires then cool and the overload relay contact automatically resets if a switch is wired for no-voltage protection. A hand reset of the overload device by means of a small button projecting through the case is provided on switches arranged for no-voltage release.



THE NEW ZO STARTING SWITCH, OPENED TO SHOW MECHANISM

The overload device protects the motor against injury due to phase failure. If an attempt is made to start the motor with one phase open, the switch will open in less than 5 sec. It is claimed that it is impossible to burn out a motor due to phase failure or overloading when protected by this starting switch.

New England Power Consolidation

THE NEW ENGLAND PUBLIC SERVICE CO. has been formed with a capital of 200,000 shares of prior lien preferred, 100,000 shares of preferred stock and 400,000 shares of common stock, to take over and consolidate the Central Maine Power & Light Co., Augusta, Me.; Manchester Traction & Light Co., Manchester, N. H.; Twin State Gas & Electric Co., Brattleboro, Vt.; Berwick & Salmon Falls Electric Co., South Berwick, Me.; Rutland

Railway, Light & Power Co., Rutland, Vt.; Vermont Hydro-Electric Corporation, Rutland, and the Pittsford Power Co., Rutland. The interests that control the Middle West Utilities Co., headed by Samuel Insull, Chicago, will operate the new organization, which has plans under way for extensions of properties, including additional transmission lines. Mr. Insull will act as chairman of the board of the new company, and W. S. Wynan, Augusta, Me., as president. Another Insull affiliation, known as the Realty Development Co., New York, has completed plans for the construction of a hydro-electric power plant on the Contoocook River, Hillsboro, N. H., comprising a series of power dams and generating stations to develop a capacity of 20,000 hp. The project is estimated to cost close to $750,000. The Vaughan Engineers, 185 Devonshire Street, Boston, Mass., are engineers in charge.

New Single Pass Boiler Has Built-In Economizer

IN THE DESIGN of the new Edge Moor single pass boiler, which has recently been placed on the market, it has been the aim of the manufacturers to embody the single pass construction in a boiler that would be within

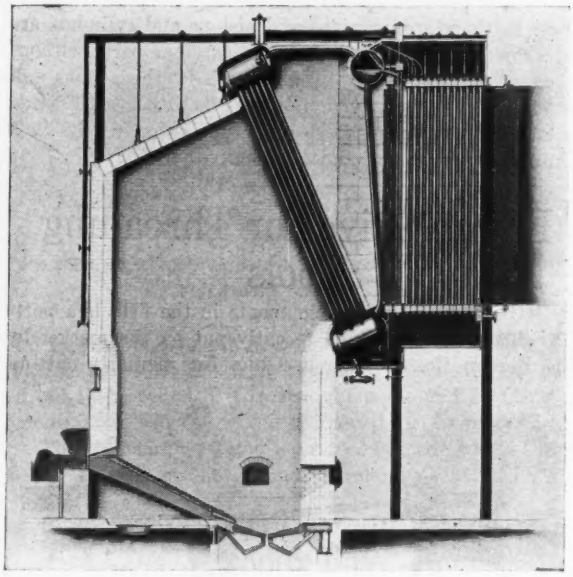


FIG. 1. SECTIONAL ELEVATION SHOWS LOCATION OF HEATING, STEAMING AND SUPERHEATER ELEMENTS WITH RELATION TO FURNACE

itself a complete steam generating unit, ready for furnace and stack connection as soon as erected. The boiler has been designed, accordingly, to consist of the following parts: (1) a heating section, proportioned to bring the entering water gradually to boiling point, having a function somewhat like that of an economizer; (2) a closed circuit steaming section; (3) a sectional counterflow superheater, provided with means for temperature control; (4) a soot-blowing system of stationary elements, with motor-operated valves; (5) a sectional steel casing and insulation; (6) appliances such as safety and blowoff valves and water columns; (7) complete structural steel supports for setting the boiler independent of building members. Each boiler is built in units, designed for a given capacity and comprising the foregoing parts.

Figures 1 and 2 show the construction of the boiler. Feed water is introduced at any temperature into the rear of the heating section. The gradual contraction of the gas passage through this section is designed to maintain high gas velocity. The water flows through this section in a sinuous path and is gradually heated as it moves forward in the section until, by the time it is ready to pass to the steaming section, its temperature is that of saturated steam. In the steaming section, the water circulates in a closed circuit entirely separate from the heating section

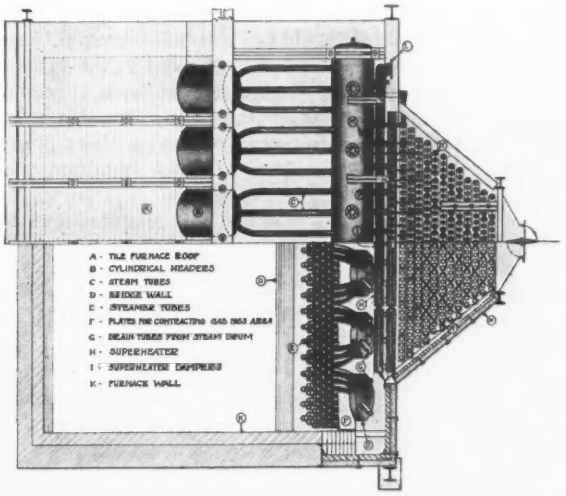

A - TILE FURNACE ROOF
B - CYLINDRICAL HEADERS
C - STEAM TUBES
D - BRIDGE WALL
E - SUPERHEATER TUBES
F - PLATES FOR CONTRACTING GAS PASS AREA
G - DRAIN TUBES FROM STEAM DRUM
H - SUPERHEATER
I - SUPERHEATER DAMPERS
K - FURNACE WALL

FIG. 2. TOP VIEW ABOVE AND HALF SECTION BELOW, SHOWING TUBE ARRANGEMENT, DAMPERS BETWEEN SUPERHEATER SECTIONS AND CONTRACTING GAS PASSAGE THROUGH HEATING SECTION

and, as steam is formed, it is carried away to the superheater. In the superheater section shown in the illustrations just in front of the heating section, the steam temperature is controlled by a set of dampers in the spaces between the groups of tubes, thus regulating the flow of gases across the tubes. These dampers are actuated by electric motors controlled by a thermostat. The soot-blowing system, built into the boiler, is divided into groups located to sweep all of the tube surface. The soot blower valves are assembled at one point and may be operated consecutively by an electric motor.

In this single pass boiler, the gas passageway is designed to make the boiler practically self-cleaning. Soot and fly ash loosened by the soot blowers are carried by the gases directly to the flue, where they can be collected by a cinder catcher and removed. No baffles of any kind are incorporated in the design. Support for the boiler is entirely from the top, all the parts expanding downward.

The heating section is composed of straight tubes assembled in short, rectangular, cast steel boxes. The steaming section is composed of relatively small diameter drums or cylindrical headers, as shown in the illustrations, each pair of headers carrying a tube bank eight tubes wide. One main drum, shown at P on Fig. 2, serves as an intermediate between heating and steaming sections and also between steaming and superheater sections. The proper water level for the boiler is also maintained in this drum. The superheater is built entirely of straight tubes rolled into steel headers, assembled in sections with control dampers be-

tween the sections. On account of this construction of the various elements, they can be combined to make a boiler of any desired width and will be manufactured for any conditions of steam generating capacity, fuel and pressure.

This boiler has been designed so that the setting can be entirely independent of the power house building members. Also, as the illustrations show, construction work can proceed on the furnace at the same time that the boiler is being erected, since brick walls are required only for the furnace itself. The boiler is furnished completely equipped with a sectional steel casing, as noted above, with suitable insulation. The design is intended to eliminate buckstays, piping and soot blower openings on the boiler casing and at the same time to give free access to every part. Clearance in front of the boiler, for tube removal, need not be provided, as there is sufficient room in the furnace and in the clear working space under the heating section for removing tubes. One advantage claimed for this boiler is that in removing a tube, it can be done without draining any of the boiler sections except the one containing that tube.

The Edge Moor single pass boiler is manufactured by the Edge Moor Iron Co., Edge Moor, Del.

Vacuum Pump for Priming Centrifugals

FOOT VALVES for holding the water in the suction pipes of centrifugal pumps add to the friction in the suction line and sometimes give trouble from being clogged

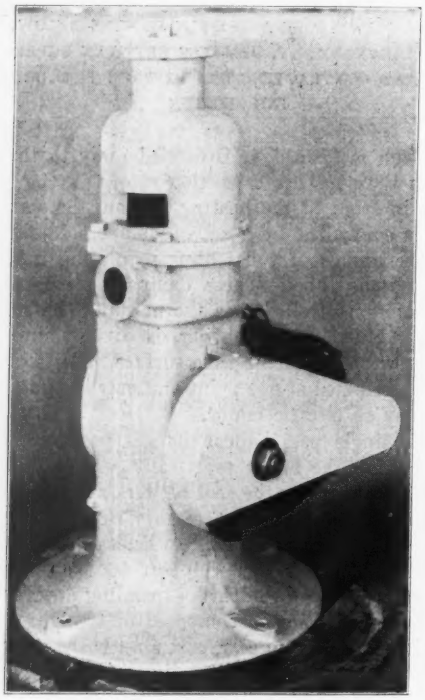


FIG. 1. A SMALL VACUUM PUMP FOR PRIMING CENTRIFUGALS

with foreign matter. This has led a number of stations to use, instead, a priming pump for removing air from the suction line, thus drawing up water to fill it.

Demand has arisen for a small size vacuum pump especially for this purpose and Barrett, Haentjens & Co. of Hazleton, Pa., announces the development of such a pump as shown in the illustrations.

From the pipe connection, shown at the left in Fig. 1, connection is made to the centrifugal pump. The two pistons, Fig. 2, draw air from the outer chamber, into which this pipe connect, and force it, through the central valves, out of the rectangular exhaust opening.

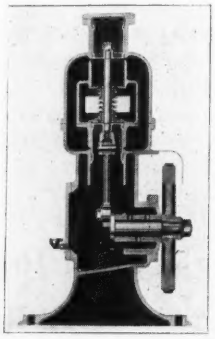


FIG. 2. INLET PORTS ARE VALVELESS AND SPRING SEATED EXHAUST VALVES ACT AS CYLINDER HEADS

This pump is of dry air type, a vacuum breaker being provided to prevent water from reaching the pump. Little power is, therefore, required and pistons and cylinders are not subject to corrosion. Inlet is through ports without valves which are alternately uncovered by the pistons and outlet is through valves at the cylinder ends, both seated by one spring. Automatic splash lubrication results in a minimum of attention and oil required.

Power Drive for Threading Tools

AMONG the recent developments in the field is a portable electric machine recently put on the market by The Borden Co. of Warren, Ohio, for regularly cutting

POWER DRIVE WILL DRIVE PIPE THREADING DIES UP TO 6 IN. DIAM.

and threading ¼ to 2-in. pipe, using any type or kind of hand operated die stocks or pipe cutters. A Universal sliding extension shaft is furnished, however, to cut and thread up to 6-in. pipe, inclusive, using geared die stocks or cutters.

In the operation of No. 44 Beaver power drive, as it is called, the pipe is inserted in the machine and rigidly held by a universal chuck. The die stock or pipe cutter is placed on the pipe as when cutting or threading by hand.

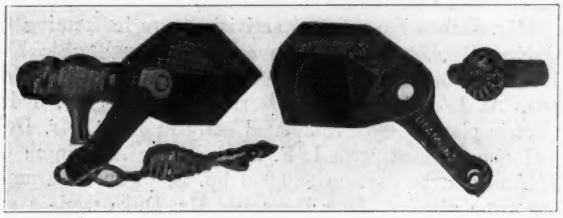
The handle of the tool rests on a sliding bar at the side of the machine. When the current is turned on the pipe revolves while the tools stand still.

By using any type or kind of die stock or pipe cutter this power drive virtually makes power machines of hand operated tools. It is also used to make up fittings right in the machine, instead of by hand, thus performing a complete job of cutting, threading and fitting without removing the pipe from the machine.

This power drive is easily portable, weighing only 230 lb. and is regularly equipped with a ½-hp. heavy duty, 110—220-v. a.c., 60-cycle, single-phase motor and is operated from an ordinary light socket. Special motor equipment is available for localities where standard equipment is not suited.

Diamond Weighted Lever Gage Cock

IN THIS gage cock, which has a soft renewable valve pencil to take the wear, the weighted lever is made with internal teeth which fit into external notches on the valve stem, thus allowing of 12 position adjustments of the weight as the pencil wears. Length of the stem and nut are such that the position of the weight can be changed by backing off the nut, disengaging the teeth and notches



THE WEIGHTED LEVER CAN BE ADJUSTED WITHOUT REMOVAL FROM THE VALVE STEM

and moving the weight to a new engagement, without removing weight or nut from the stem. To reseat the pencil, all that is needed is to straighten the end by filing or grinding and when worn out the pencil can be renewed.

The Diamond weighted lever cock is made by the Cleveland Flue Cleaner Mfg. Co. of Cleveland, Ohio.

Maine Votes to Develop Passamaquoddy Bay

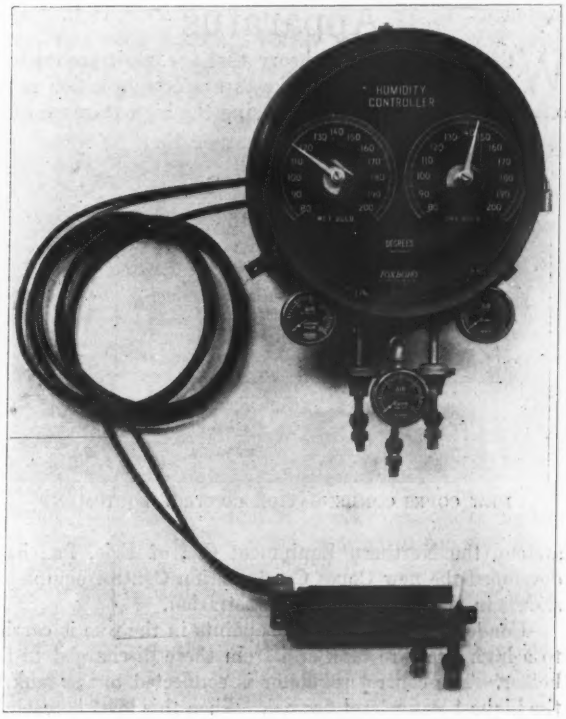
THE REFERENDUM authorizing Dexter P. Cooper, Inc., to develop and utilize the power of the tides in the Bay of Fundy and adjacent thereto, more particularly those of Passamaquoddy Bay, for the manufacture of electrical current and also for the right to transmit power so manufactured outside the state of Maine, was officially passed by the voters of that state in the special election in September by a vote of Yes, 53,547; No, 7,220, according to complete tabulation of the vote reported by the Secretary of the State of Maine. The project was approved in every one of the 16 counties.

It is proposed to establish a $100,000,000 plant and transmission service and already New York bankers are studying the financing of the undertaking. New York engineers have reported in favor of the project, declaring that 500,000 hp. can be generated by the proposed use of the tides and that by linking up the Cooper project with Niagara on the west, the most densely populated section of the United States may be served.

As previously reported in Power Plant Engineering, the Cooper project would enclose two large bays in Passamaquoddy Bay converting them into reservoirs with dam and spillway between. The upper bay would be flooded at high tide and the gates then closed, the water flowing over the dam into the lower basin which would be emptied at low tide, maintaining a differential in the water levels of the two reservoirs which would at no time be less than 12 ft.

Humidity Controller of the Indicating Type

NON-RECORDING humidity controllers characterized by the following points are a recent development of the Foxboro Co.: 1. The wet and dry bulb scales are separate and calibrated for the entire range of the instrument.



WET AND DRY BULB SCALES ARE SEPARATE

Each scale has an individual setting arm. 2. The temperature elements are replaceable as a unit. Easily removed from and replaced in the case, they do not necessitate disturbing the other parts when overhauling. 3. There is used neither rubber tubing nor any other material which will deteriorate. 4. They can be used with a psychrometer already in service by applying an adapter to the psychrometer water-box.

Farm Electrification Experiment Starts in Oklahoma

DEFINITE STEPS toward establishing experimental farm electrification lines in Oklahoma were taken at a conference between representatives of the electric light and power companies of the state, the board of agriculture, the Agri-

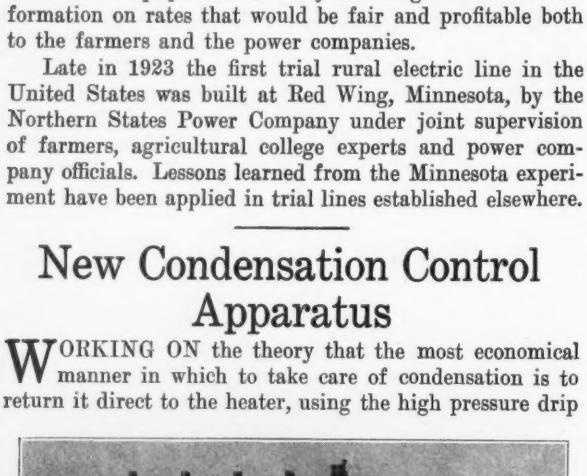
cultural and Mining College, farm organizations and farm publications, held in Oklahoma City recently.

O. A. Jennings, manager of the commercial department of the Oklahoma Gas and Electric Company, was appointed a member of a committee of three to make a survey and recommend the proper locations for the lines. The purpose of the experimental lines would be to determine to what extent the farms are willing to take the service, also the class of equipment necessary and to gain scientific information on rates that would be fair and profitable both to the farmers and the power companies.

Late in 1923 the first trial rural electric line in the United States was built at Red Wing, Minnesota, by the Northern States Power Company under joint supervision of farmers, agricultural college experts and power company officials. Lessons learned from the Minnesota experiment have been applied in trial lines established elsewhere.

New Condensation Control Apparatus

WORKING ON the theory that the most economical manner in which to take care of condensation is to return it direct to the heater, using the high pressure drip



NEW COPES CONDENSATION CONTROL EQUIPMENT

system, the Northern Equipment Co., of Erie, Pa., have developed the new Copes Condensation Control equipment shown in the accompanying illustration.

Condensation from various points in the line is carried to a high pressure tank and from there discharged to the heater. The control regulator is connected to the tank at the highest water level desired. When this level is reached, the regulator, actuated by a thermostatic expansion tube, opens and the level is lowered.

This condensation control operates exactly opposite to a feed water regulator in that it regulates the discharge from the tank and not the supply. The control valve has a special nickel steel wall and seat in place of the sleeve valve used in the control valves of boiler feed water regulators. This specially designed valve is necessarily of small area, due to the high pressure drop across the valve. This is from line pressure to practically atmosphere .

D. K. Chadbourne Made Westinghouse International Manager

DEAN K. CHADBOURNE has been appointed general manager of the Westinghouse Electric International company to succeed E. D. Kilburn who was recently elected vice-president of the Westinghouse Electric and Manufacturing Co., according to announcement from the Westinghouse International Co.'s headquarters.

Mr. Chadbourne was born in Elmira, N. Y., and graduated from Purdue University in 1906 with the degree of Bachelor of Science in Electrical Engineering. He was for 6 yr. connected with the Chicago office of the Allis-Chalmers Co. and then became district manager of the George Cutter Co. of South Bend, Ind. In 1920 he joined the Westinghouse Electric International Company and was made manager of the Far Eastern Department.

Death of James B. Duke

ON SATURDAY, October 10, James B. Duke, promoter and capitalist, died at his home in New York City. Mr. Duke was born in Durham, N. C., in 1857. After building up, with his father and brothers, a tobacco business that attained great proportions, Mr. Duke, in 1904, convinced of the importance of water power in developing the cotton industry of the South, formed the Southern Power Co., which has had since that time a steady growth and an important influence on southern power developments.

Hydro-electric plants of all types and sizes were built or acquired by the company and steam stations were added where needed, until at the end of the last year the company had a total generating capacity of 705,000 hp., with 125,000 hp. more under construction.

Mr. Duke's most recent activities were in forming the Quebec Development Co., in conjunction with Sir Wm. Price of Montreal, to develop the Saguenay River in Canada. At Isle Maligne on this river a 540,000-hp. hydro-electric plant will be completed early in 1927. Mr. Duke had also planned, with I. E. Davis of the Aluminum Co. of America, to develop 800,000 hp. at Chute-à-Caron in the same district. Last December Mr. Duke made a gift of $40,000,000, including three-quarters of his holdings in the Southern Power Co., to Trinity (now Duke) University of Durham, N. C.

News Notes

THE ROBERT JUNE ENGINEERING MANAGEMENT ORGANIZATION of Detroit, has acquired control of the Electric Flow Meter Co. at Kansas City, Mo., formerly the Hyperbo-Electric Flow Meter Co. of Chicago, and will henceforth operate the business under its own management with executive offices at 8835 Linwood Ave., Detroit, Mich. Robert June becomes president of the company, J. M. Naiman, formerly general manager, becomes vice president, consulting and chief engineer with Major W. W. Burden, of the Robert June Organization, as treasurer.

REPRESENTATIVES RECENTLY appointed by the American Engineering Co., of Philadelphia, for the sale of its "Lo-Hed" hoist are as follows: All-Steel Equipment Co., 86 State St., Albany, N. Y.; American Machinery & Supply Co., 1113 Howard St., Omaha, Neb.; Ambler & Riter, Kearns, Bldg., Salt Lake City, Utah; Dravo-Doyle Co., 749 Leader-News Bldg., Cleveland, O.; Dravo-Doyle Co., 705 Merchants Bank Bldg., Indianapolis, Ind.; Factory Supply Co., 2122 Avenue D, Birmingham, Ala.; C. Fuson Co., 404 Fidelity Bank Bldg., Memphis, Tenn.; Gibbens & Gorden, Inc., 534 Canal St., New Orleans, La.; Industrial Products Corp., 1205 Chamber of Commerce, Pittsburgh, Pa.; Menner & Kimball, Syndicate Trust Bldg., St. Louis, Mo.; Standard Steel & Supply Co., 29th

Street and C. & O. R. R., Ashland, Ky.; C. Turner & Co., Power Bldg., Chattanooga, Tenn.; S. R. Vanderbeck, 20-22 S. 15th St., Philadelphia, Pa.; Wylie Bros., 511 N. Main St., Oklahoma City, Okla. A representative of the hoist department also has been added to the staff of the American Engineering Co.'s Chicago office, 1401-1402 Marquette Bldg.

JOHNS-PRATT COMPANY of Hartford removed its New York office, Eastern District, on October 1, from 41 East Forty-second St., to 20 Vesey St., New York City.

C. J. PRIEBE has recently become associated with the Ross Heater & Mfg. Co. of Buffalo, N. Y., as a sales engineer in the Metropolitan District with offices at 2 Rector St., New York City.

THE BUNDY STEAM TRAP CO. has recently appointed as agents in its respective territories, The Reed Engineering & Supply Co., 12 Amherst St., Worcester, Mass., and The Hauer Power Equipment Co., Union Trust Bldg., Cincinnati, Ohio.

THE UNION BAG & PAPER CO., Cheboygan, Mich., is increasing its steam generating capacity by the addition of one 450-hp. Heine water-tube boiler, equipped with a Taylor stoker. This unit will increase the capacity of the boiler plant to 2500 hp.

JOSEPH MCKAY, JR., has become associated with the Liberty Electric Corporation of Stamford, Conn., as New York and Philadelphia district sales representative on Liberty valve operators and control equipment. Mr. McKay's headquarters will be at the offices of the company at 342 Madison Ave., New York City.

THE FREEMAN SWEET CO. of Chicago, has decided to discontinue its wholesale electrical supply business and confine its activities to electrical contracting in the future. The entire wholesale sales personnel of the Freeman-Sweet Co. joined the organization of the American Electrical Supply Co., 117 So. Morgan St., Chicago, Monday, October 12.

ANNOUNCEMENT HAS been made by Gerard Swope, president of the General Electric Co., that orders received by that company for the three months ending September 30, amounted to $73,561,483 compared with $58,389,832 for the same quarter in 1924, which shows an increase of 26 per cent. For the first nine months of the present year, orders totaling $223,876,711 were received as compared with $203,097,719 for the same period in 1924, showing an increase of 10 per cent.

CONTRACT HAS been awarded by the Insull interests in New Hampshire to the L. H. Shattuck Co., of Manchester, N. H., for a series of dams and power houses on the Contoocook River at Hillsboro, N. H. The project will require about a year to complete and more than 20,000 hp. will be developed. The development is known as the Jackman development and is under the direction of the Vaughan Engineers, 185 Devonshire St., Boston, for the Realty Development Co., of New York, a subsidiary of the Insull interests.

AFTER 20-YR. of operation, the state of Iowa has abandoned its generating plant, maintained to supply light and power for the state capitol and surrounding grounds and public buildings in Des Moines, Ia. The state executive council after a study of costs in which it was assisted by the electrical engineering department of the Iowa State college, signed a contract with the Des Moines Electric Light Co. for the purchase of all of its energy.

Twenty-three Iowa cities and towns have abandoned municipal electric lighting establishments during the past year, making a total of 87 such instances in the state. The latest case is that of the town of Struble, the citizens of which, on September 24, voted to sell its system to the Iowa Light, Heat & Power Company.

OUTSTANDING FEATURES of the annual meeting of the American Society of Mechanical Engineers, to be held in New York City, November 30 to December 4, will be the conferring of honorary membership on Hon. Herbert Hoover and on past president Worcester R. Warner. This will take place Tuesday evening, December 1, preceding the address of president William F. Durand. Tuesday p. m. at 4:30, the first Henry R. Towne lecture on Engineering and Economics will be delivered and Thursday afternoon at the same hour, the Robert Henry Thurston lecture on Engineering and Science.

On Wednesday evening, December 2, the annual dinner will be held and on Thursday evening a National Defense session. Other sessions will cover Machine Shop and Design; Management Industrial Processes in materials handling, wood working, textile manufacture and aeronautics; fuel and power.

For entertainment, a get-together meeting on Monday evening and various inspection trips are planned. Also, for the ladies, luncheon, tea and a reception on Wednesday with sight-seeing and shopping trips about the city on other days.

METROPOLITAN SECTION, A.S.M.E., will hold a meeting at 29 West 39th St., New York, on November 12, the subject being "Subterranean Heat as a Source of Energy." Speakers will be L. P. Breckenridge, George Otis Smith and J. D. Galloway.

ANNOUNCEMENT HAS RECENTLY been made by the Southern Power Co. that an 80,000-hp. steam electric power plant will be built as soon as possible in order to create a reserve that will provide ample insurance against any possibility of power curtailment in the future. This decision has been made as a result of the unprecedented drought which has prevailed in the southern states for the past several months. The exact location of the new plant has not as yet been announced but it is probable that its location will be somewhere on the Catawba River where condensing water is available.

THE CENTRAL MAINE POWER CO., with headquarters in Lewiston, Me., has awarded contract for the construction of a dam across the Androscoggin River at the "Gulf," a few miles above Lewiston, to the Morton C. Tuttle Co., of Boston, Mass. The dam will be 50 ft. high with a new power house to be erected on the Lewiston shore. The development will generate 27,000 hp., said to be exceeded only by the Rumford Falls plant in point of size and capacity in the state at present. A short branch line railroad will be built to aid in the construction of the dam. Work will start immediately.

PLANS HAVE been consummated for a merger of the West Missouri Power Co., Pleasant Hill, Mo., with the Missouri Power & Light Co., operating at Mexico, Mo., and vicinity. The change will be made on November 1. The West Missouri company was organized in 1917 and is now furnishing service to more than 60 communities in Western Missouri, including Warrensburg, Harrisonville and Clinton. A central station is operated at Pleasant Hill. The acquiring company is one of the Studebaker-McKinley interests.

Books and Catalogs

PRINCIPLES OF MACHINE DESIGN, by C. A. Norman; 6 by 8½ in., cloth, 710 pages, 104 tables, 585 illustrations; first edition, New York, 1925.

For some time there has been considerable need manifested in the engineering colleges for a textbook on machine design that would give the student reliable data on the methods and principles employed in the design of the types of machinery that he will encounter as soon as he enters industry.

To get this information at first hand, the author of this book went direct to the manufacturers, who supplied him with data, drawings and photographs of their latest equipment. A brief discussion of materials is followed by interesting chapters on plate vessels, bolts and screws, cylinders, springs, pistons, cranks and shafts and so on down through the list of machine elements to piping. As a typical example, the author's discussion of gearing is to be commended, for he brings out clearly the recent work with the Maag tooth system, the helical gear and the worm gear, and provides in a comparatively few pages a much clearer and more practical discussion of gearing than we have seen in other volumes on the subject.

This volume is included in the Engineering Science Series, edited by D. C. Jackson and E. R. Hedrick. We can recommend it heartily, to all those interested in machine design, as a practical and authoritative treatment.

REFRIGERATING PLANT LUBRICATION, a bulletin just issued by the Vacuum Oil Co., presents a most exhaustive treatise on every phase of the subject, illustrated with line drawings of all types of refrigerating equipment.

CATALOG N of the Reliance Gauge Column Co., Cleveland, O., contains about everything a man would need to know about Reliance steam specialties including water column, water gauges, gauge cocks and floats, their construction, installation, and operation.

THE DIAMOND POWER SPECIALTY CORP., Detroit, Mich., has reprinted a bulletin entitled "The Best Paying Investment in the Power Plant." This bulletin features Diamond Valv-in-Head blowers and contains information and data which should be of interest and value to the power operator.

RUGGLES-KLINGEMANN MFG. CO., Boston, Mass., is distributing to architects, engineers, paper mills and public utility plants a blue print pamphlet showing applications of R-K temperature and pressure control regulators, chronometer valves and other control equipment. The pamphlet is made up of loose-leaf sheets which may be used as instructions for installing the various devices.

THE BROWN INSTRUMENT CO., Philadelphia, Pa., has just issued a bulletin under the title, "Approval Deserves Weight—Coming from Those Who Know," describing the Brown electrical CO_2 meters. The bulletin contains statements from various users of these instruments and points to the savings which have been accomplished with the use of these recorders.

SCHUTTE AND KOERTING CO. of Philadelphia, Pa., is distributing two unusually interesting prices of literature covering products of its manufacture. Bulletin No. 4-F contains a description of the thermo-compressor illustrated with colored line drawing to show its application in the power plant and other industries. A snapshot of Mechanical Appliances for the Oil Industry is the title of a booklet in which the company describes its oil, gas, gasoline, by-product and power plant equipment including heat exchangers, condensers, oil burners, evaporators, feed water heaters, valves, spray systems and other appliances.

CECIL R. LAMBERT CO. of Detroit, Mich., has just issued a pamphlet on conveyor applications which is of interest to every executive who wishes to lower his material handling costs.

HARNISCHFEGER CORP., Milwaukee, Wis., has just issued two attractive bulletins, No. 41X dealing with corduroy cranes and 82X with shovels. Both of these bulletins are well illustrated to describe the equipment and its application.

STATEMENT OF THE OWNERSHIP, MANAGEMENT, CIRCULATION, ETC.

required by the Act of Congress of August 24, 1912, of Power Plant Engineering, published semi-monthly, at Chicago, Ill., for October 1, 1925.

State of Illinois,
County of Cook,
ss.

Before me, a Notary in and for the state and county aforesaid, personally appeared Charles S. Clarke, who, having been duly sworn according to law, deposes and says that he is the Secretary of the Power Plant Engineering, and that the following is, to the best of his knowledge and belief, a true statement of the ownership, management (and if a daily paper, the circulation), etc., of the aforesaid publication for the date shown in the above caption, required by the Act of August 24, 1912, embodied in section 443, Postal Laws and Regulations, printed on the reverse of this form, to-wit:

1. That the names and addresses of the publisher, editor, managing editor, and business managers are:
Publisher, Technical Publishing Co., Chicago, Ill.
Editor, Arthur L. Rice, Chicago, Ill.
Managing Editor, R. E. Turner, Chicago, Ill.
Business Manager, E. R. Shaw, Chicago, Ill.

2. That the owners are: (Give names and addresses of individual owners, or, if a corporation, give its name and the names and addresses of stockholders owning or holding 1 per cent or more of the total amount of stock.)
Technical Publishing Company, Chicago, Ill.
E. R. Shaw, Chicago, Ill.
Arthur L. Rice, Chicago, Ill.
K. L. Rice, Chicago, Ill.
Charles S. Clarke, Chicago, Ill.

3. That the known bondholders, mortgagees, and other security holders owning or holding 1 per cent or more of total amount of bonds, mortgages, or other securities are: (If there are none, so state.)
There are none.

4. That the two paragraphs next above, giving the names of the owners, stockholders, and security holders, if any, contain not only the list of stockholders and security holders as they appear upon the books of the company but also, in cases where the stockholder or security holder appears upon the books of the company as trustee or in any other fiduciary relation, the name of the person or corporation for whom such trustee is acting, is given; also that the said two paragraphs contain statements embracing affiant's full knowledge and belief as to the circumstances and conditions under which stockholders and security holders who do not appear upon the books of the company as trustees, hold stock and securities in a capacity other than that of a bona fide owner; and this affiant has no reason to believe that any other person, association, or corporation has any interest direct or indirect in the said stock, bonds, or other securities than as so stated by him.

5. That the average number of copies of each issue of this publication sold or distributed through the mails or otherwise, to paid subscribers during the six months preceding the date shown above is..... (This information is required from daily publications only.)

Chas. Sanford Clarke, Secretary.

Sworn to and subscribed before me this 26th day of September, 1925.

James S. Valentine.

(My commission expires September, 1925.)

NOTE.—This statement must be made in duplicate and both copies delivered by the publisher to the postmaster, who shall send one copy to the Third Assistant Postmaster General (Division of Classification), Washington, D. C., and retain the other in the files of the postoffice. The publisher must publish a copy of this statement in the second issue printed next after its filing.

Sparks from the Advertising Pages

Where Buyers and Sellers Meet

The Latest Record of Things Accomplished

Cycles evolve, from time to time, that far-seeing men turn to their advantage. Races, nations, industries and institutions have their crucial periods of growth.

Unseen forces develop through the years until they reach a height of potentiality and a degree of balance that suddenly make possible unthought-of developments.

World-wide forces have shaped the present cycle of opportunity in the power industry.

Initiative, enterprise, intensified interest and sustained energy on the part of the majority of power plant men are keeping power generation and distribution apace with its opportunities.

Vast, substantial growth throughout powerdom is rapidly making actualities out of possibilities and disclosing greater possibilities ready to be turned into further developments.

In the stupendous activities of the immediate future there are no booms or sinecures.

Rather it is the opening of a period of greater responsibility and alertness on the part of every man in the industry who would be favored by events.

Closer linking of thought, deeper seated recognition of the common interests of us all and a more open-minded and helpful attitude is required, not for success alone, but for survival.

To promote more rapidly that better understanding which makes possible the growth of individuals, institutions and the power industry as a whole, is the purpose of the Six Feature Numbers of Power Plant Engineering.

Each of these numbers has its definite purpose and together they will constitute a cycle of profound influence in power generation.

For it is in the judgments of you, the readers of these pages, to determine not only what your individual plants shall be but, by the preponderance of your opinions as executives of the larger and more progressive plants of the greatest power generating country in the world, to determine what the future of power shall be in the social and economic life of the people.

Manufacturers of power plant machinery, equipment and supplies will place the results of the best of their experience, specialized ability and manufacturing resources before you in the Six Feature Numbers of Power Plant Engineering, in full knowledge that service to you and your plants is the final test of all their striving and skill.

Never was there a time in the history of power development when the products of manufacturers represented such close study of the practical requirements of power plants, such a wealth of inventive genius, such careful tests and such certainty of results, as now.

And in the presentation of these products to you in the advertisements now being prepared for your consideration in the Six Feature Numbers of Power Plant Engineering, there was never a time when such care was being taken to make them clear, concise, easy to read and of greatest service on your problems, as now.

Men who manufacture the products advertised here, who prepare the advertising, who will meet you at the two great power shows and who call on you in your offices as representatives of these products, are technically trained men, men of practical experience, men who make your problems their problems, and whose keen observation and wide opportunities for exercising it have given broad viewpoints and intensified power to be helpful.

Like the men who prepare the editorial pages, they have gained their experience from the ground up in laboratories, foundries and shops; by first-hand contact with the products they help to create, from blue print to tests and years of observation of them in the power plants they serve.

Meet these men in the printed word and face to face with the frankness and open-mindedness of workers in a common cause and in the security of a common sincerity.

Look forward to the Nov. 15, New York Power Show Announcement Number and the succeeding Five Feature Numbers, as practical utilities from cover to cover.

Machinery, Equipment and Supplies Used In The Production and Transmission of Power

Under the heading of each product listed will be found the names of the manufacturers of that product. The index to advertisers, next to the back cover, gives the page numbers on which the manufacturers' descriptive advertisements appear.

AIR COMPRESSORS.
Allen & Billmyre Co., Inc., The, New York.
Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Bethlehem Shipbuilding Corp., Bethlehem, Pa.
Dean Bros. Co., Indianapolis.
De Laval Steam Turbine Co., Trenton, N. J.
Murray Iron Works Co., Burlington, Iowa.
Worthington Pump & Machinery Corp., New York, N. Y.
Yeomans Bros., Co., Chicago.

AIR FILTERS.
Allen & Billmyre Co., Inc., The, New York.
Cooling Tower Co., Inc., New York.
Spray Engineering Co., Boston.

AIR WASHERS.
Badger & Sons Co., E. B., Boston, Mass.
Buffalo Forge Co., Buffalo.
Cooling Tower Co., Inc., The, New York.
Spray Engineering Co., Boston.

ALARMS, HIGH AND LOW WATER.
Hills-McCanna Co., Chicago, Ill.
Huyette Co., Inc., The Paul B., Philadelphia, Pa.
Northern Equipment Co., Erie.
Reliance Gauge Column Co., Cleveland, Ohio.
Wright-Austin Co., Detroit.

ARCHES, BOILER COMBUSTION.
Betson Plastic Fire Brick Co., Inc., Rome, N. Y.
Brady Conveyors Corp., Chicago.
Detrick Co., M. H., Chicago.
Harbison - Walker Refractories Co., Pittsburgh, Pa.
Hofft Co., The M. A., Indianapolis, Ind.
Liptak Fire Brick Arch Co., Mexico, Mo.
McLeod & Henry Co., Troy, N. Y.
Pilbrico Jointless Firebrick Co., Chicago, Ill.
Queen's Run Refractories Co., Inc., Lock Haven, Pa.
Quigley Furnace Spec. Co., New York.

ASH AND COAL BINS.
Frederick Iron & Steel Co., Frederick, Md.

ASH BIN GATES AND DOORS
Allen-Sherman-Hoff Co., The, Philadelphia, Pa.
Beaumont Mfg. Co., Philadelphia, Pa.
Brady Conveyors Corp., Chicago.
Frederick Iron & Steel Co., Frederick, Md.
Hagan Co., George J., Pittsburgh.
United Conveyor Corp., Chicago.

ASH HANDLING SYSTEMS.
Allen-Sherman-Hoff Co., The, Philadelphia, Pa.
Beaumont Mfg. Co., Philadelphia, Pa.
Brady Conveyors Corp., Chicago.
Conveyors Corp. of America, Chicago.
Detrick Co., M. H., Chicago.
Frederick Iron & Steel Co., Frederick, Md.
Hagan Co., George J., Pittsburgh.
Link-Belt Co., Chicago, Ill.
Stephens-Adamson Mfg. Co., Aurora, Ill.
United Conveyor Corp., Chicago.
Webster Mfg. Co., The, Chicago.

ASH TANKS.
Conveyors Corp. of America, Chicago.
Hagan Co., George J., Pittsburgh.
United Conveyor Corp., Chicago.

BABBITT METAL.
Magnolia Metal Co., New York.

BAROMETERS.
Taylor Instrument Co's., Rochester, N. Y.

BEARING METAL.
Magnolia Metal Co., New York.
Strong, Carlisle & Hammond Co., The, Cleveland, Ohio.

BELT CONVEYORS.
Stephens-Adamson Mfg. Co., Aurora, Ill.
Webster Mfg. Co., The, Chicago.

BELT DRESSING.
Cling-Surface Co., Buffalo, N. Y.
Dixon Crucible Co., Jos., Jersey City, N. J.
Standard Oil Co. (Indiana), Chicago, Ill.
Stephenson Mfg. Co., Albany.

BELT LACING.
Bristol Co., The, Waterbury.

BELTING.
Quaker City Rubber Co., Phila.
United States Rubber Co., New York, N. Y.

BELTING, SILENT CHAIN.
Link-Belt Co., Chicago, Ill.
Morse Chain Co., Ithaca, N. Y.

BLOWERS, FAN AND FURNACE.
Buffalo Forge Co., Buffalo.
Coppus Engineering Corp., Worcester, Mass.

BOILER FEEDWATER PURIFYING APPARATUS.
Griscom-Russell Co., New York.
Paige & Jones Chem. Co., New York.
Permutit Co., The, New York.
Power Plant Specialty Co., Chicago, Ill.

BOILER FRONTS.
McLeod & Henry Co., Troy, N. Y.

BOILER MOUNTINGS.
Lunkenheimer Co., Cincinnati.

BOILER SETTING CEMENT.
Betson Plastic Fire Brick Co., Rome, N. Y.
Botfield Refractories Co., Philadelphia, Pa.
General Refractories Co., Philadelphia, Pa.
Harbison - Walker Refractories Co., Pittsburgh, Pa.
Huyette Co., Inc., The Paul B., Philadelphia, Pa.
Pilbrico Jointless Firebrick Co., Chicago, Ill.
Queen's Run Refractories Co., Inc., Lock Haven, Pa.
Quigley Furnace Spec. Co., New York.

To Find the Manufacturers' Advertisements of Products Listed Here, See Index Page 154

De Laval Steam Turbine Co., Trenton, N. J.
Terry Steam Turbine Co., The, Hartford, Conn.
Wing Mfg. Co., L. J., New York.

BLOWERS, FORCED DRAFT
Sturtevant Co., B. F., Boston.

BLOWERS, PORTABLE.
Allen & Billmyre Co., Inc., The, New York.
Buffalo Forge Co., Buffalo.
Clements Mfg. Co., Chicago, Ill.
Sturtevant Co., B. F., Boston.

BLOWERS, STEAM.
Schutte & Koerting Co., Phila.

BLOWERS, TUBE.
Bayer Co., The, St. Louis, Mo.
Diamond Power Specialty Corp., Detroit.
Marion Mach., Fdry. & Supply Co., Marion, Ind.
Vulcan Soot Cleaner Co., Du Bois, Pa.
Webster, Howard J., Philadelphia, Pa.

BLOWERS, TURBINE.
Allen & Billmyre Co., Inc., The, New York.
Moore Steam Turbine Corp., Wellsville, N. Y.
Wing Mfg. Co., L. J., New York.

BOILER BAFFLES.
Betson Plastic Fire Brick Co., Rome, N. Y.
Johns-Manville, Inc., New York.
McLeod & Henry Co., Troy, N. Y.
Quigley Furnace Spec. Co., New York.

BOILER CAP CLEANERS.
Lagonda Mfg. Co., Springfield, Ohio.

BOILER COMPOUNDS.
Botfield Refractories Co., Philadelphia, Pa.
Dearborn Chemical Co., Chicago.
Hawk-Eye Compound Co., Blue Island, Ill.
McLeod & Henry Co., Troy, N. Y.
Paige & Jones Chem. Co., New York.

BOILER COMPOUND FEEDERS.
Hills-McCanna Co., Chicago, Ill.

BOILER SETTINGS.
Betson Plastic Fire Brick Co., Rome, N. Y.
Botfield Refractories Co., Philadelphia, Pa.
General Refractories Co., Philadelphia, Pa.
Harbison - Walker Refractories Co., Pittsburgh, Pa.
McLeod & Henry Co., Troy, N. Y.
Pilbrico Jointless Firebrick Co., Chicago, Ill.
Queen's Run Refractories Co., Inc., Lock Haven, Pa.
Quigley Furnace Spec. Co., New York.
Webster, Howard J., Philadelphia, Pa.

BOILER SKIMMERS.
Sims Co., The, Erie, Pa.

BOILER TUBE CLEANERS.
Condenser Cleaners Mfg. Co., Pittsburgh.
Lagonda Mfg. Co., Springfield, Ohio.
Liberty Mfg. Co., Pittsburgh.
Pierce Co., The Wm. B., Buffalo, N. Y.
Roto Co., The Hartford, Conn.

BOILER TUBES.
Babcock & Wilcox Tube Co., The, Beaver Falls, Pa.
Bethlehem Steel Co., Inc., Bethlehem, Pa.
Murray Iron Works Co., Burlington, Iowa.
Scully Steel & Iron Co., Chicago.

BOILER WALL COATINGS.
Botfield Refractories Co., Philadelphia, Pa.
Johns-Manville, Inc., New York.

BOILERS.
Babcock & Wilcox Co., New York.
Badenhausen Corp., Philadelphia, Pa.
Bigelow Co., The, New Haven.
Casey-Hedges Co., The, Chattanoogs, Tenn.
Connelly Boiler Co., The, D., Cleveland, Ohio.
Edge Moor Iron Co., Edge Moor, Del.
Erie City Iron Works, Erie, Pa.
Freeman Mfg. Co., Racine, Wis.
Heine Boiler Co., St. Louis.
Kingsford Fdry. & Mach. Co., Oswego, N. Y.
Murray Iron Works Co., Burlington, Iowa.
Union Iron Works, Erie, Pa.
Webster, Howard J., Philadelphia, Pa.
Wickes Boiler Co., The, Saginaw, Mich.

BOOKS AND SCHOOLS.
Audel & Co., Theo., New York.

BREECHINGS.
Littleford Bros., Cincinnati.

BRICKS, FURNACE LINING.
Norton Co., Worcester, Mass.

BRUSHES, DYNAMO & MOTOR.
Dixon Crucible Co., Jos., Jersey City, N. J.

BRUSHES, GRAPHITE.
Dixon Crucible Co., Jos., Jersey City, N. J.

BRUSHES, WIRE.
Pilley Pkg. & Flue Brush Mfg. Co., St. Louis, Mo.

BUCKET ELEVATORS.
Link-Belt Co., Chicago, Ill.
Webster Mfg. Co., The, Chicago.

CARRIERS, PIVOTED BUCKET.
Webster Mfg. Co., The, Chicago.

CASTINGS.
Bethlehem Steel Co., Inc., Bethlehem, Pa.
Fuller-Lehigh Co., Fullerton, Pa.
Hills-McCanna Co., Chicago, Ill.
Neemes Fdry, Inc., Troy, N. Y.

CEMENT, FURNACE.
Betson Plastic Fire Brick Co., Rome, N. Y.
Botfield Refractories Co., Philadelphia, Pa.
General Refractories Co., Philadelphia, Pa.
Harbison - Walker Refractories Co., Pittsburgh, Pa.
McLeod & Henry Co., Troy, N. Y.
Norton Co., Worcester, Mass.
Pilbrico Jointless Firebrick Co., Chicago, Ill.
Queen's Run Refractories Co., Lock Haven, Pa.
Quigley Furnace Spec. Co., New York.

CEMENT GUNS.
Cement-Gun Co., Inc., The, Allentown, Pa.

CEMENT, HIGH TEMPERATURE.
Botfield Refractories Co., Philadelphia, Pa.
General Refractories Co., Philadelphia, Pa.
Harbison - Walker Refractories Co., Pittsburgh, Pa.
McLeod & Henry Co., Troy, N. Y.
Norton Co., Worcester, Mass.
Pilbrico Jointless Firebrick Co., Chicago, Ill.
Quigley Furnace Spec. Co., New York.

CEMENT, IRON.
Smooth-On Mfg. Co., Jersey City, N. J.

CHAIN WHEELS.
Babbitt Steam Specialty Co., New Bedford, Mass.

CHAINS, DRIVE.
Link-Belt Co., Chicago, Ill.
Morse Chain Co., Ithaca, N. Y.

CHIMNEYS.
American Chimney Corp., New York, N. Y.
Bigelow Co., The, New Haven.

CLEANERS, BOILER TUBE.
General Specialty Co., The, Buffalo, N. Y.
Lagonda Mfg. Co., Springfield, Ohio.
Liberty Mfg. Co., Pittsburgh, Pa.
Pierce Co., The Wm. B., Buffalo, N. Y.
Roto Co., The, Hartford, Conn.

CLEANING COMPOUNDS.
Dearborn Chemical Co., Chicago.

COAL AND ASH HANDLING MACHINERY.
Allen-Sherman-Hoff Co., The, Philadelphia, Pa.
Beaumont Mfg. Co., Philadelphia, Pa.
Brady Conveyors Corp., Chicago.
Conveyors Corp. of Amer., Chicago.
Detrick Co., M. H., Chicago.
Fairbanks-Morse & Co., Chicago.